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## The taxonomy of *Boronia anemonifolia* and *B. rigens* (*Boronia* sect. *Cyanothamnus*, Rutaceae)

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### Abstract

The taxonomy of *Boronia anemonifolia* A. Cunn. and *B. rigens* Cheel are discussed. Two new subspecies, *B. anemonifolia* subsp. *aurifodina* P.G.Neish and *B. anemonifolia* subsp. *wadbilligensis* P.G.Neish are described, and *B. anemonifolia* var. *variabilis* (Hook.f.) Benth. is raised to subspecific rank. All subspecies of *B. anemonifolia* are illustrated. The original description of *B. rigens* Cheel was based on discordant elements, and so is also revised. *Boronia anemonifolia*, *B. variabilis*, *B. polygalifolia* Sm. var. *robusta* Benth., *B. dentigera* F. Muell., and *B. dentigeroides* Cheel are lectotypified.

### Introduction

While revising the east coast species of *Boronia* Sm. sect. *Cyanothamnus* (Lindl.) F. Muell. for the *Flora of Australia* treatment of Rutaceae it became apparent that the circumscriptions of a number of taxa needed revision. Here, we revise *B. anemonifolia* A. Cunn. and *B. rigens* Cheel. The remaining east coast species of *Boronia* sect. *Cyanothamnus* are discussed in a forthcoming paper by Duretto, except for *B. coerulescens* F. Muell. which was revised by Wilson (1998).

### Material and Methods

**Material:** Herbarium specimens were made available from AD, BRI, CANB, HO, LUND, MEL, NE, NSW, PERTH and TCD; cibachromes and 35 mm transparencies were received from K, and 35 mm transparencies were received from BM. Herbarium abbreviations follow Holmgren *et al.* (1990). These specimens were augmented with material collected in the field from the entire range of each taxon. Five plants per population were collected where possible.

**Leaf Anatomy:** The central portion of leaves of all taxa were fixed in 70% ethanol. Fixed material was dehydrated through a graded ethanol series up to 100% ethanol, infiltrated with 100% LR-White (London Resin) through a resin/ethanol series, and polymerised at 60°C. Sections 2 µm in thickness were cut on a Reichert Ultracut ultra-microtome and stained with 0.05% toluidine blue solution (pH 4.4).

**Taxonomic Descriptions:** Descriptive terminology follows Briggs and Johnson (1979) and Weston (1990) for inflorescence structure, and Murley (1951) for seed surfaces. Conservation codes follow the format of Briggs and Leigh (1996).

### Taxonomy

**1. *Boronia anemonifolia*** A. Cunn. in B. Field, *Geographical Memoirs of New South Wales* 330 (1825). *Type citation*: "Verge of the Regent's Glen, Blue Mountains." *Type*: Regents Glen, Blue Mountains, N.S. Wales, A. Cunningham No.43, Oct.1822 (lectotype, here designated, K, ex. hb. cunningham., n.v., (cibachrome MEL 2047064, photograph AD); isolectotypes MEL 256802, NSW); rocky declivities and precipitous descents, ? A. Cunningham (probable isolectotype K n.v. (cibachrome MEL 2047065; photograph AD 99543144)).

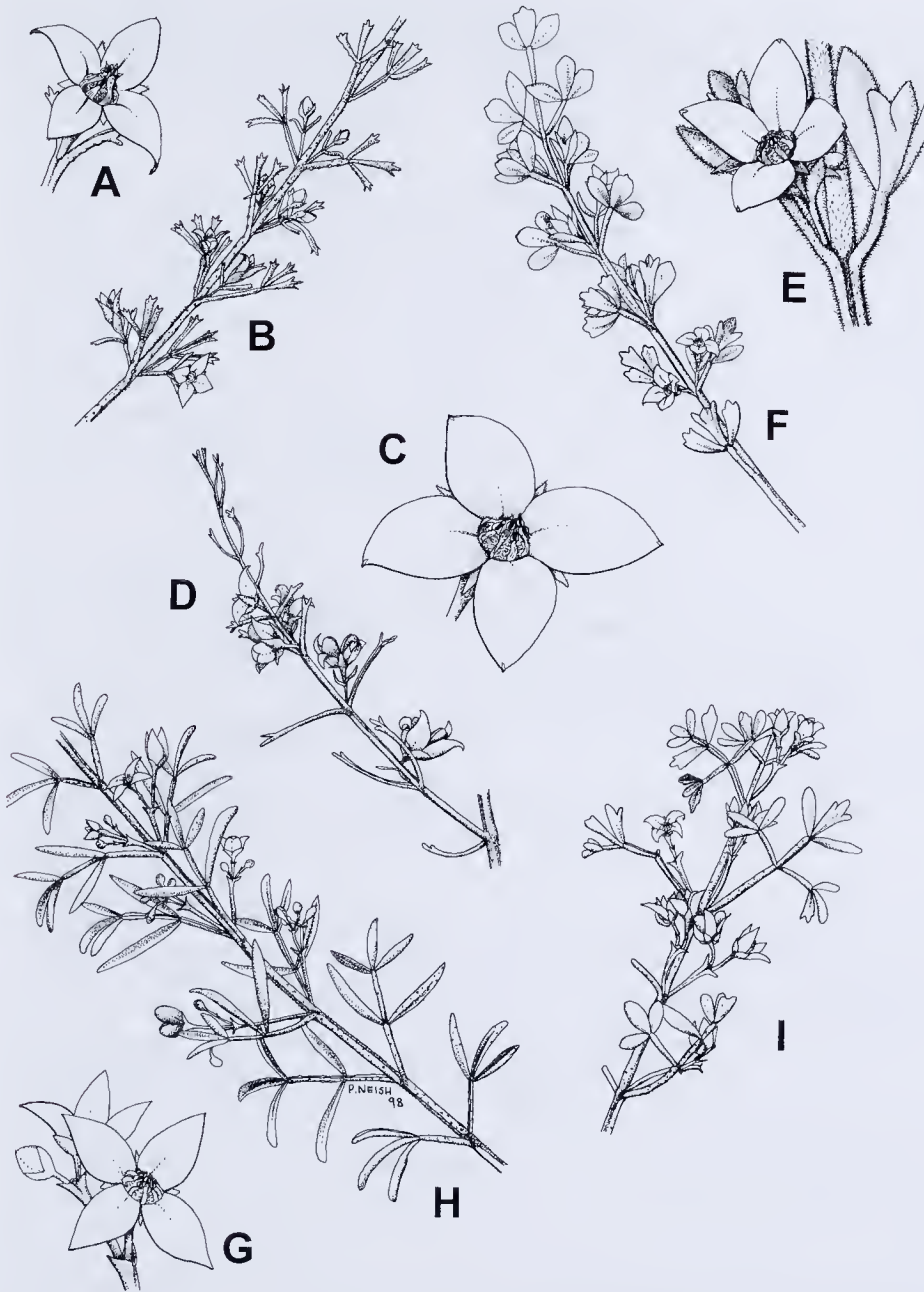
Erect, much branched *shrub* to 2.5 m tall, the branches terete to slightly quadrangular

with moderate cork development on older branches, the stems and leaves glandular punctate; the whole plant glabrous to pubescent, with hairs often restricted to area between the decurrent leaf bases on stems, larger stems becoming glabrous with age, all hairs simple, erect, straight or curved, to 0.5 mm. *Leaves* simple or 3–5-foliolate, or bipinnate with the lower leaflets ternate, the leaf in outline 4–18(–35) mm long, 2–25(–30) mm wide; petiole 2–9(–16) mm long, canaliculate above; rachis segments 3–7 mm long, canaliculate above, sometimes winged, widest at distal end; leaflets or simple leaves narrow-cuneate to cuneate or narrow-elliptic to elliptic or ovate or obovate, strongly conduplicate or plane, concolourous, dorsiventral, 2–9(–13) mm long, 1–4(–6) mm wide, tip often divided into three acute to obtuse lobes (Fig. 1), midrib slightly raised abaxially, spongy mesophyll continuous under midvein. *Inflorescence* axillary, 1–6(–9+)-flowered; peduncle 1–8 mm long; prophylls unifoliolate or tridentate, persistent with mature fruit, 0.5–5(–8) mm long, to 1.5(–3) mm wide; metaxephylls to 0.5 mm long, sometimes absent; anthopodium 0.5–4(–6) mm long. *Sepals* broad-ovate, imbricate in bud, persistent with mature fruit, 1.5–2.5(–3.0) mm long, 0.8–1.5 mm wide, 1/5 to 2/3 of the length of the petals, tip acuminate; adaxial surface glabrous or margins ciliate or sparsely to densely puberulous; abaxial surface glabrous or sparsely puberulous. *Petals* white to pink, imbricate in bud, persistent or caducous with mature fruit, (3.5–)4–5.5(–6.5) mm long, 2–3 mm wide, midvein not raised on abaxial surface; adaxial surface with few scattered simple appressed hairs; abaxial surface glabrous or glabrescent or sparsely puberulous; tip with a small but distinct incurved hook. *Stamens* 8, erect, all fertile; filaments gradually tapering to anther connective, pilose on margins below slightly glandular tip, antesealous filaments 1.3–2 mm long, antepetalous filaments 1.0–1.5 mm long; anthers attached subapically on filament, anther connective maroon; anther-apiculum prominent, glabrous or with a few simple hairs. Disc entire, glabrous, entirely within staminal whorl. *Ovary* glabrous, or with a few hairs between carpels; style pilose at base; stigma rounded, as wide or slightly wider than style. *Cocci* glabrous or with a few simple hairs along suture, 3–5 mm long, 1.8–2.2 mm wide. *Seeds* elliptical in outline, 2.5 mm long, 1.2–1.5 mm wide, black to black-brown, dull, slightly tuberculate, without wax crystals between tuberculae.

*Typification:* A single collection was cited in the protologue of *B. anemonifolia*: “Verge of the Regent’s Glen, Blue Mountains.” Cunningham collections (Cunningham 43) matching this information are lodged at K, MEL and NSW. The specimen lodged at K is in excellent condition, was part of Allan Cunningham’s Australian herbarium and is designated the lectotype. Another specimen lodged at K, with only ‘rocky declivities and precipitous descents’ written on a label, was annotated by Melville in 1955 who stated it was part of the type. The specimen is probably part of the type collection and is here considered to be a probable isoelectotype.

*Taxonomic History:* *Boronia anemonifolia* has a complex taxonomic history. Cunningham (1825) characterised *B. anemonifolia* as having trifoliolate leaves with each leaflet divided into two or three at the apex. Later, Hooker (1834) described a similar taxon from Tasmania as *B. variabilis* Hook. and Mueller (1855) described *B. dentigera* F. Muell. from Victoria. Mueller (1860–62) placed these latter two species, along with *B. anemonifolia*, *B. tetrahecodes* DC. (= *B. polygalifolia* Sm.), *B. lyssopifolia* Sieber ex J.D. Hook. (= *B. nana* Hook. var. *lyssopifolia* Melville), *B. nana*, and *B. bipinnata* Lindl. in synonymy under *B. polygalifolia*, concluding that *B. polygalifolia* was “one of the most variable species of the vegetable kingdom”. He retained this synonymy in his ‘Census of Australian Plants’ (Mueller 1882, 1889) and in his ‘Key to...Victorian Plants’ (Mueller 1888). Bentham (1863) did not follow Mueller, and instead divided *B. anemonifolia* into, what he called, three ‘tolerably distinct races’: viz. var. *dentigera* (F. Muell.) Benth. (which included *Cyanothamnus tridactylitis* Bartl., = *Boronia anemonifolia* subsp. *anemonifolia*) from New South Wales, Victoria, Tasmania and Western Australia; var. *variabilis* (Hook.) Benth. (see subsp. *variabilis* (Hook.) P.G. Neish) from Tasmania; and





**Figure 1.** Habit and flowers of *B. anemonifolia*. **A–B** *B. anemonifolia* subsp. *anemonifolia*: **A** flower  $\times 3$  (Neish *et al.* 42, MEL 2032477); **B** habit  $\times 1$  (Coveny 11044, CANB 333125); **C–D** *B. anemonifolia* subsp. *aurifodina*: **C** flower  $\times 3$  (Neish *et al.* 20, MEL 2032453); **D** habit  $\times 1$  (holotype, Corrick 7892, MEL 603327); **E–F** *B. anemonifolia* subsp. *wadbilligensis*: **E** flower  $\times 3$  (Neish *et al.* 44, MEL 2032480); **F** Habit  $\times 1$  (holotype, Telford 3661, CANB); **G–H** *B. anemonifolia* subsp. *variabilis* (Tasmania): **G** flower  $\times 3$  (Neish *et al.* 68, MEL 2032648); **H** habit  $\times 1$  (Moscal 8395, HO 403360); **I** *B. anemonifolia* subsp. *variabilis* (New South Wales): habit  $\times 1$  (Coveny *et al.* 16565, CANB 468216)

var. *auethifolia* (Lindl.) Benth. (= *B. anethifolia* Lindl.) from Queensland and New South Wales. The Western Australian distributional data was based on his and Bartling's (1848) erroneous assumption that the type of *C. tridactylitis* was from Western Australia. Baker (1899) extended the range of var. *dentigera* to include Mittagong and Sugar Loaf Mountain near Braidwood. Ewart (1930) adopted Bentham's (1863) varieties in his 'Flora of Victoria'.

Rodway (1903) lists two varieties of *B. anemonifolia* in Tasmania, viz. var. *dentigera* and var. *variabilis*. Curiously, Rodway (1903) includes *B. variabilis* Hook. in synonymy under var. *variabilis* but does not include *B. dentigera* F. Muell. in synonymy under var. *dentigera*. Both of these varietal combinations had been made by Bentham (1863), but it cannot be assumed that Rodway was aware of these combinations. Reference to the work of Bentham is absent from the entire Rutaceae section of his work. He is inconsistent throughout his treatment in including synonymies and authors, and in author abbreviations. Rodway (1903) did make a new combination, *B. pinnata* Sm. var. *citriodora* (Hook.) Rodway, but he did not state it was new. As it cannot be assumed that Rodway (1903) was or was not intentionally describing new combinations, var. *dentigera* (F. Muell.) Rodway (see subsp. *anemonifolia*) and var. *variabilis* (Hook.) Rodway (see subsp. *variabilis*), are considered to be illegitimate names. Of these two varietal names only the latter is listed by Chapman (1991).

Cheel (1928) reinstated *B. dentigera* and described *B. dentigeroides* Cheel which was "similar in general appearance to *B. dentigera* but the leaves are more compound, being twice ternate, and the leaflets more or less flattened and dentate at the apex". *Boronia dentigeroides* and *B. dentigera* were placed in synonymy under *B. anemonifolia* by Willis (1957). Willis (1973), following Bentham (1863), retained *B. anemonifolia* var. *variabilis*, noting that it graded into the *dentigeroides* form of *B. auenouifolia* through the Furneaux group in Bass Strait. Curtis (1975) adopts a broad view of the species and recognises no varieties for Tasmania, while Weston and Porteners (1991) indicate that *B. anemonifolia* var. *anemonifolia* is the only variety found in New South Wales.

Four subspecies of *B. anemonifolia* are recognised in this treatment, including two newly described. The rank of subspecies is considered appropriate due to the presence of gradation between subspecies. For example subsp. *auenouifolia* grades into subsp. *variabilis* throughout east Gippsland in Victoria and in the south-east New South Wales, while subsp. *aurifodina* approaches subsp. *anemonifolia* in central Victoria. Morphology is consistent within populations and it seems that intermediates are not the result of hybrids, but simply a product of the variability of the species.

*Distribution and ecology:* *Boronia anemonifolia* is found in south-eastern Australia from near Warwick (SE Qld), through eastern New South Wales and eastern and central Victoria, to the islands of Bass Strait and northern and eastern Tasmania (Fig. 2). It is mainly found growing on and around sandstone and granite outcrops in eucalypt woodland or forest, where it can be the dominant component of the shrubby understorey, or heath or shrubland in exposed areas. It flowers for most of the year, but mainly from August to February. Fruiting specimens have been collected between October and January.

*Etymology:* The specific epithet alludes to the resemblance of the leaves to those of species of *Anemone* L. (Ranunculaceae).

### Key to subspecies

1. Leaves simple or if trifoliate then petiole very much longer than leaflets; petals 5–6 mm long (central Vic.) ..... **1b.** subsp. *aurifodina*
1. Leaves trifoliate, pinnate or bipinnate, petiole c. same length as leaflets; petals (3.5–)4–5.5(–6.5) mm long (NSW, Vic., Tas.) ..... **2**
2. Petals not persistent with mature fruit. inflorescence (1–)3–6(–9+)-flowered;



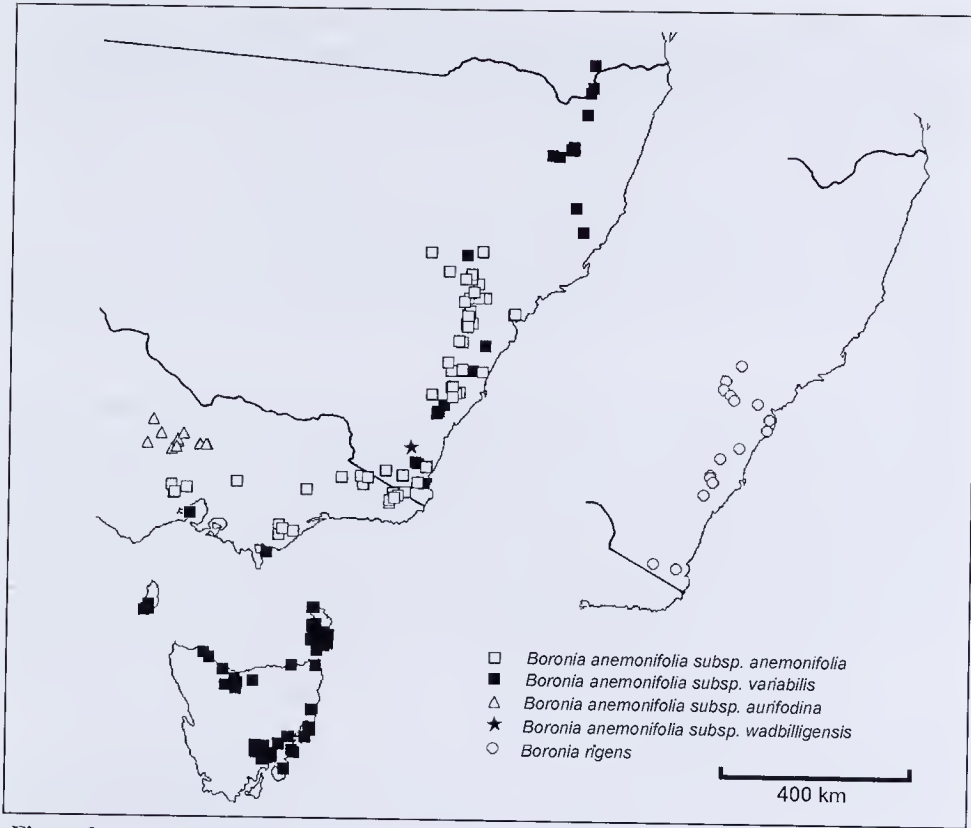


Figure 2. Distribution of *Boronia anemonifolia* and *B. rigens*.

prophylls simple, to 1.5 mm long; sepals 1–2 mm long, 1/5 to 1/3(–1/2) of the length of the petals; leaflets glabrous (rarely glabrescent) (Qld, NSW, Vic., Tas.).....

- ..... **1d. subsp. *variabilis***  
 2: Petals persistent with mature fruit, inflorescence 1–3(–6)-flowered; prophylls simple or tridentate, usually 1–8 mm long; sepals 1.5–3 mm long, (1/4–)1/2–3/4 length of petals; leaflets glabrescent to pubescent (NSW, Vic.) ..... 3  
 3. Leaflets strongly conduplicate, < 2 mm wide, lateral leaflets usually tridentate (NSW, Vic.) ..... **1a. subsp. *anemonifolia***  
 3: Leaflets flat, 2–5 mm wide, fleshy, lateral leaflets usually entire (Wadbilliga Plateau, NSW) ..... **1c. subsp. *wadbilligensis***

**1a. *Boronia anemonifolia* A. Cunn. subsp. *anemonifolia*.** *Cyanothamnus tridactylites* Bartl. in Lehmann, *Pl. Preiss* 2, 227. (1848). *Type citation*: “In regionibus interioribus Australiae meridionali-occidentalis m. Octobri a. 1840. hb. Preiss No. 2628”. *Type*: hb. preiss. 2628 (holotype LD 95036-0984 transparencies MEL 2044581, NSW; isotype MEL 256803).

*Boronia dentigera* F. Muell., *Trans. & Proc. Victorian Inst. Advancem. Sci.* 32 (1855). *Type citation*: “On sandhills near the La Trobe River, and in McCrae’s Island. Also, near the Pendland [Pentland] Hills according to Mr. Dallachi.” *Type*: Latrobe River, F. v. Mueller [26.iv.1853] (lectotype, here designated, MEL 257409); Latrobe River, F. v. Mueller, May 1853 (syntype K n.v. (photograph AD 99548108); McCrae’s Island, F. Mueller, v.1853 (syntype MEL 257413); Gippsland, Nov. Holl. aust., Dr F. Mueller

[1853?] (probable syntypes MEL 257411, MEL 257412 (both from Sonder's herbarium)); Between Bacchus Marsh and Pentland Hills [Myrniong], F.v. Mueller [1853] (possible syntype MEL 256801); Wimmera River, N.W. Vict., Dallachy [1853?] (possible syntype MEL 257410 (from Sonder's herbarium)). *B. anemonifolia* var. *dentigera* (F. Muell.) Benth., *Fl. aust.* 1: 321 (1863).

*B. anemonifolia* var. *dentigera* (F. Muell.) Rodway, *Tasmanian Fl.* 22 (1903) *nomen illeg.*, non *B. anemonifolia* var. *dentigera* (F. Muell.) Benth. (1863).

*Boronia anemonifolia* ssp. A (Typical Form) *sensu* Ross (1996, p. 129).

*Illustrations*: G.R. Cochrane, B.A. Fuhrer, E.R. Rotterham & J.H. Willis, *Flowers and Plants of Victoria* t. 309 (1968); A. Fairley and P. Moore, *Native Plants of the Sydney District*, 235, t. 817 (1989); P.H. Weston and M.F. Porteners, *Fl. New South Wales* 2: 230 (1991).

*Shrub* to 1.5 m tall. Branches glabrous or glabrescent or pubescent between decurrent leaf bases, leaves glabrescent to pubescent. *Leaves* trifoliolate or rarely bipinnate with the lower leaflets ternate, the leaf in outline 4–15(–20) mm long, 2–14(–19) mm wide; petiole 2–7(–10) mm long; leaflets strongly conduplicate or rarely flattened, narrow-cuneate, often canaliculate, tips tridentate; terminal leaflet 2–7(–9) mm long, 1–2(–2.5) mm wide, about as long as lateral leaflets. *Inflorescence* 1–3-flowered; peduncle 1–8 mm; prophylls often tridentate, (1–)2–5(–8) mm long, glabrescent to pubescent; anthopodium 1–5 mm long. *Sepals* glabrous or margins ciliate, or sparsely to moderately densely pubescent, 1.5–2(–3) mm long, 0.8–1.4 mm wide, (1/4–)1/2 the length of the petals. *Petals* glabrous or with few hairs along midrib or at tip, (3.5–)4–5.5(–6.5) mm long, 2–2.5(–3) mm wide, persistent with mature fruit.

*Selected specimens examined (of c. 250 collections)*: **NEW SOUTH WALES**: Rylstone Dam on Cudgegong River, near wall, *J.H. Willis s.n.*, 6.x.1969 (MEL); Bundanoon Creek, below Echo Pt., *Constable s.n.*, 26.i.1956 (NSW 36706); Blue Mountains, at base of Fort Rock, near Blackheath, 33°38'08"S 150°16'23"E, *P.G. Neish 33 M.F. Duretto & I Thompson*, 28.x.1995 (MEL); 200m W of Pass, c. 3km E of Endrick R. on Braidwood-Nerriga Rd, 35°05'S 150°08'E, *P.G. Neish 40 M.F. Duretto & I Thompson*, 30.x.1995 (MEL, NSW, CANB); Tianjara Falls, along track heading N from falls along cliff line, 35°08'S 150°20'E, *R.J. Rudd 241*, 17.xi.1992 (CANB); Dr Georges Mountain summit, 36°40'S 149°54'E, *N.G. Walsh 1675*, 2.xii.1986 (BRI, HO, MEL); mountain peak 2.5km direct NE of Mount Poole, Yambulla State Forest, 37°11'30"S 149°32'15"E, *J.D. Briggs 1996 & D. Albrecht*, 21.vii.1986 (CANB); **VICTORIA**: Jawbones, *R. Webb 4 & E. Richards*, 26.ix.1965 (CANB); Brisbane Ranges NP, 4 km along Reids Road, going SW along the road from Rowsley, 37°44'S 144°19'E, *V. Stajsic 496*, 27.ix.1991 (AD, BRI, CANB, MEL, NSW); near summit of northern end of Cathedral Range, *T.B. Muir 2554*, 4.viii.1962 (MEL); Ballantyne Hills, Suggan Buggan, *A.E. Orchard 2491*, 25.viii.1970 (AD); Nunniong Plateau, along saddle running north c. 1 km east of end of Brumby Point track, 37°03'20"S 148°05'00"E, *M.G. Corrick 10164*, 2.i.1987 (MEL); Mt Kaye, East Gippsland, *N.A. Wakefield 3532*, 20.x.1946 (MEL); 5 miles [c. 8 km] ESE of Rosedale Post Office, 1 mile N of Limestone Quarry Road, *A.C. Beaglehole 38190*, 16.ii.1972 (MEL); Holey Plains Park, Pipeline Trk near intersection with Rosedale-Stradbroke Rd, 38°13'S 146°52'E, *P.G. Neish 81 & A. Vadala*, 11.iv.1996 (MEL); Holey Plains State Park, Chessum Road, 0.2 km west of its junction with Kelly track, T18, 38°13'20"S 146°55'00"E, *M.G. Corrick 9991 & B.J. Conn*, 14.x.1986 (CANB, MEL); slopes above south bank of Yambulla Creek, c. 200 m within Victoria, c. 2 km SW of Yambulla Peak, 37°16'50"S 149°23'30"E, *N.G. Walsh 2136*, *D. Albrecht & J. Westaway*, 9.ix.1988 (CANB, HO, MEL).

*Notes*: *Boronia anemonifolia* subsp. *anemonifolia* is variable in leaf size and in the number and shape of the leaflets. The various forms grade into each other. A typical specimen is illustrated in Figure 2(A, B). *Boronia dentigera* was based on one of these forms. Plants matching the type of *B. dentigera* are found at Holey Plains State Park near Sale in eastern Victoria. These plants are notable in having very pink petals, even when dry, pubescent foliage and a prostrate habit and may warrant further investigation.

Bentham (1863) and Rodway (1903) both state that *B. anemonifolia* var. *dentigera* (=

subsp. *anemonifolia*) is found in Tasmania, however all Tasmanian specimens examined are referable to the subsp. *variabilis* (see notes under subsp. *variabilis*).

*Distribution and ecology*: This subspecies is found on the tablelands and in coastal areas south from Rylstone (NSW), through eastern Victoria and west to the Brisbane Ranges. It is found on sandy or rocky soils in dry woodlands or heath often on exposed sandstone or granitic outcrops.

At MEL there is a collection of *B. anemonifolia* subsp. *anemonifolia* that was supposedly collected from the Grampians (W Vic.): viz. Grampians, *Miss Cowle s.n.*, x.1904 (MEL). Other collections made at the "Jawbones" (eg. *R. Webb 4* & *E. Richards* [CANB]) have also been assumed to have come from the Grampians. The "Balconies" or "Asses ears" in the Grampians sometimes go by the name of the "Jawbones", but here the "Jawbones" are more likely to be from the Cathedral Ranges (south-central Victoria), where a number of collections of subsp. *anemonifolia* have been made. A search of the "Jawbones" in the Grampians did not locate any trace of this species. The only specimen seen of subsp. *anemonifolia* from the Northern Tablelands of New South Wales is from Mt Spirabo (*E.F. Constable s.n.* NE 29213). However, this specimen is a duplicate of a specimen lodged at NSW (NSW 56122) which is referable to subsp. *variabilis*. These two specimens are clearly not from the same plant and the absence of any other specimens of subsp. *anemonifolia* in the Northern Tablelands suggests that this record is spurious. A search of the area around Mt Spirabo located only subsp. *variabilis*.

*Conservation status*: *Boronia anemonifolia* subsp. *anemonifolia* is a fairly common subspecies that is adequately represented in reserves across its entire range.

**1b. *Boronia anemonifolia* subsp. *aurifodina* P.G. Neish subsp. nov.**

A varietate typica foliis unifoliatis vel petioli quam foliolis multo longioribus, petalis 5–6 mm longis differt.

*Type*: Victoria: Rushworth Forest, west of Bailieston, 36°45'S, 144°56'E, *M.G. Corrick* 7892, 25.x.1981 (holotype MEL 603327; isotypes HO 52023, AD 98230303).

*Boronia anemonifolia* ssp. C (Rushworth) *sensu* Ross (1996, p. 129).

*Shrub* to 1.2 m tall. Branches glabrous or pubescent between decurrent leaf bases. *Leaves* simple with trifid tips, though first few leaves on branches can be trifoliate with leaflets very much smaller than petiole, entire leaf 5–15 mm long, simple leaves 0.5–2.5 mm wide, trifoliate leaves to 6 mm wide; petiole 3–12 mm long; leaflets strongly conduplicate or flattened, very narrow-cuneate to 3 mm long, 0.5–2 mm wide if leaf compound. *Inflorescence* (1–)3(–6)-flowered; peduncle 1–4 mm; prophylls simple, 1.5–5(–7) mm long, sometimes tridentate, glabrous or pubescent; anthopodia 1–3 mm long. *Sepals* glabrous or margins ciliate or sparsely to densely pubescent, 1.5–2.5 mm long, 1.0–1.5 mm wide, c. 1/3 of the length of the petals. *Petals* 5–6 mm long, 3–4 mm wide, glabrous or glabrescent, persistent with mature fruit.

*Other specimens examined*: **VICTORIA**: Inglewood Flora Reserve, N of Rifle Range along Kingower Rd. c. 1.5 km SW of Town Centre, H36, *N.G. Walsh* 2451, 25.viii.1987 (MEL); Historic area, Castlemaine-Chesterton area, *A.C. Beanglehole* 69011, *E.R. Perkin* & *F.H. Blake*, 2.ix.1981 (MEL); Puzzle Flat, Bealiba, *J.H. Willis s.n.*, 4.ix.1936 (MEL); Murderer's Hill, Dunolly, *M.E. Phillips* 424–425, 20.ix.1961 (CANB); Mandurang, Koolamurt Park, Spring Gully Reservoir, M38, 36°49'S 144°18'E, *J. Samson s.n.*, 2.x.1997 (MEL 2042600); McEldrew's Paddock, 1 mile [c. 1.6 km] NE of Eaglehawk near Bendigo, *R. Melville* 1248, *P. Morris*, *M. Cohn*, *H. Henkel* & *W. Perry*, 30.ix.1952 (K n.v., MEL); c. 18.5km SSW of Bendigo P.O., *A.C. Beanglehole* 50092, 2.viii.1975 (MEL); Lightning Hill Road, Bendigo, *F. Robbins* ACB 7259, 11.ix.1947 (MEL); Diamond Hill, 17 km SSW of Bendigo, *A.C. Beanglehole* 50045, 29.vii.1995 (MEL); Moornbool, 36°48'S 144°54'E, *N.A. Wakefield s.n.*, ix.1939 (QRS 14601); Kamarooka S.F., c. 400 m N of Campbell's Rd on road to Kamarooka, 36°34'S 144°23'E, *P.G. Neish* 17 & *K.R. Henshall*, 6.viii.1995 (MEL, NSW); Whipstick, *F. Robbins* ACB7266, 25.ix.1949 (MEL); Central Whipstick, along road 5, *W. Perry s.n.*, 10.ix.1961 (MEL 530742); Rushworth State Forest, between main Graytown-Whroo



Road and Darrochs (Derricks) Dam, *J.H. Willis s.n.*, 4.ix.1974 (MEL); Graytown State Forest, S of intersection of Old Kilmore Road with Graytown-Rushworth Road, 36°44'S 144°57'E, *R.J. Fletcher 153*, 23.viii.1993 (MEL); Rushworth State Forest, on Whroo-Graytown Rd, corner of Darrochs Rd and extending to Johnson's Reef Road, 36°45'S 144°47'E, *R.J. Fletcher 4*, 4.x.1991 (MEL, PERTH); Rushworth forest reference area, M42, *A.C. Beaglehole 69729*, 4.xi.1981 (CANB, MEL); 4.5 miles [c. 7.2 km] SE of Maldon, M46, *F. Filson 5111*, 17.viii.1963 (MEL).

*Notes:* *Boronia anemonifolia* subsp. *aurifodina* is segregated on the basis of its simple, strongly conduplicate leaves with tips divided into three very small points (Fig. 2D), and its larger petals (5–6 mm long). (Fig. 2C). Specimens from the Rushworth Forest have consistently simple foliage while those from the other populations often have trifoliate leaves on the first few nodes of a branch. Plants from the Castlemaine area approach subsp. *anemonifolia* in leaf shape, but are distinguished by having a petiole much longer than the leaflets.

*Distribution and ecology:* The subspecies is confined to central Victoria in the goldfields area and is common in the Rushworth State Forest and widespread through the "Whipstick Forest" around Bendigo (Fig. 2). It is found in low open eucalypt woodland with a diverse understorey. The populations of this subspecies west of Bendigo towards Wedderburn represent the western most occurrence of *B. anemonifolia*.

*Conservation status:* *Boronia anemonifolia* subsp. *aurifodina* is restricted in range and is found mainly in state forests. Due to uncertainty regarding the long-term protection provided by State Forests the subspecies is regarded as not adequately preserved. Monitoring of all known populations is necessary to determine the viability of this subspecies and a management plan might be appropriate. A conservation code of 2R is considered appropriate at this stage.

*Etymology:* The subspecific epithet is derived from the Latin for gold-mine *aurifodina* (*aurum* (gold) and *fodire* (to dig)), and refers to the subspecies being confined to the goldfield region of central Victoria.

**1c. *Boronia anemonifolia* subsp. *wadbilligensis* P.G. Neish subsp. nov.**

A varietate typica foliolis applanatis latoribus (2–5 mm latis) differt.

*Type:* SE of Wadbilliga Trig, 46km ESE of Cooma, South Coast, New South Wales, 36°23'S 149°35'E, *I. R. Telford 3661* 19.xi.1973 (holotype CANB, transparency MEL 2059439; isotypes PERTH *n.v.*, K *n.v.*, L *n.v.*, A *n.v.*)

*Shrub* to 1(–2) m tall. Branches pubescent, hair density greater between decurrent leaf bases, becoming glabrous with age. *Leaves* glabrescent to pubescent, 3–5-foliate, the leaf in outline 8–18 mm long, 4–10(–18) mm wide; petiole 3–8 mm long; leaflets flattened, entire or tridentate at tip, obovate, oblanceolate or euneate; terminal leaflet 4–9 mm long, 2–4(–6) mm wide, shorter or the same length as the lateral leaflets. *Inflorescence* (1–)3-flowered; peduncle 3–5 mm long; prophylls simple or tridentate, glabrescent to pubescent, 3–6 mm long, 1–1.5(–3) mm wide; anthopodium 2–3.5 mm long. *Sepals* 2–3 mm long, 1.0–1.5 mm wide, 1/2 to 3/4 the length of the petals; abaxial surface moderately densely pubescent. *Petals* (4–)4.5–5(–6) mm long, 2–3 mm wide, persistence unknown; abaxial surface sparsely pubescent with hairs concentrated along the midrib. Fruit and seed not seen.

*Other Specimens Examined:* NEW SOUTH WALES, SOUTHERN TABLELANDS: A prominent bluff 2.4 km direct north of Wadbilliga trig, 36°19'S 149°36'E, *J.D. Briggs 1818* and *P.H. Weston*, 27.iii.1985 (CANB, HO, MEL, NSW); Spur SE of Wadbilliga trig., 36°20'S 149°36'E, *D.F. Blaxell 491*, 25.iv.1971 (CANB, MEL, NSW); c. 0.5 km north of Wadbilliga trig, *P. Gilmour W057*, 22.iv.1983 (CANB); Wadbilliga NP, Brogo Wilderness area, c. 15 km direct ENE of Kybean beside Razor Back Fire Trail, 36°20'S 149°36'E, *S. Donaldson 662*, *D. Mallinson*, *A.M. Lyne & I.R. Telford*, 15.xii.1995 (CANB *n.v.*, MEL, NSW *n.v.*, PERTH *n.v.*); Wadbilliga trig. fire trail, 14 km E of Tuross River crossing, 36°21'S 149°37'E, *M.D. Crisp 1238* and *I.R. Telford*, 30.ix.1975

(CANB); On rocky outcrop on Spur 1.5 km SE of Wadbilliga trig., 36°21'S 149°37'E, P.G. Neish 44, M. Duretto & I. Thompson, 1.xi.1995 (MEL); Head of Tuross River, R.H. Cambage s.n., xi.1908 (NSW); Northern end of Wadbilliga Mtn Plateau, I. Olsen 2373, 13.x.1974 (NSW).

*Notes:* *Boronia anemonifolia* subsp. *wadbilligensis* differs from subsp. *anemonifolia* in having pinnate leaves with wider and thicker leaflets (2–5 mm wide) and usually entire lateral leaflets, and from subsp. *variabilis* by the pubescent leaves, petals, and the longer prophylls and sepals (Figs. 2E, F).

*Distribution and ecology:* This subspecies is restricted to the Wadbilliga Plateau in south-eastern New South Wales (Fig. 2). It is found in eucalypt woodland or low *Allocasuarina nana* (Sieber ex Sprengel) L. Johnson heath on rocky outcrops and ridge tops between 1200 and 1300 m. Flowering material has been collected in October and December.

*Conservation status:* All known collections of *B. anemonifolia* subsp. *wadbilligensis* have been made within five kilometres of each other in Wadbilliga National Park. A conservation code of 2RC+ is appropriate. Further field work is required to ascertain the full range of this subspecies.

*Etymology:* The subspecific epithet is derived from the name of the major landmark, the Wadbilliga trig. point, within the distributional range of this subspecies.

**1d. *Boronia anemonifolia* subsp. *variabilis* (Hook.) P.G. Neish, comb. nov.** *Boronia variabilis* Hook., J. Bot. (Hooker) 1: 255 (1834). *Type citation:* “Mr. Lawrence, (1831), Mr. Gunn, (n. 8.) - β Mr. Gunn, (n. 214) - γ Mr. Gunn, (n. 303.), who observes that it is called Lemon-plant.” *Type:* Van D. Land [Tasmania], Mr Gunn n. 214 (lectotype, here designated and by implication by Hooker, J. Bot. (Hooker) 2, 418 (1840), K (*ex hb. hook.*, 4 sprigs on lower half of sheet) *n.v.*, cibachrome MEL 2041296. *B. anemonifolia* var. *variabilis* (Hook.) Benth., *Fl. aust.* 1: 321 (1863).

*B. anemonifolia* var. *variabilis* (Hook.) Rodway, *Tasmanian Fl.* 22 (1903) *nom illeg.* non *B. anemonifolia* var. *variabilis* (Hook.) Benth. (1863).

*Boronia dentigeroides* Cheel, *J. Roy. Soc. N.S. Wales* 62: 301 (1929). *Type citation:* “Braidwood, W. Baeuerlen [sic]; Clyde Mountain, near Nelligen, J.L. Boorman; Belmore Falls, W. Forsythe; Menangle, Mr. Harper; Timburra (Stuart) ex Herb. Melbourne, labelled *B. polygalifolia* var. *anemonifolia*; Flinder’s Island (Gulliver), labelled *B. anemonifolia*.” *Type:* Timburra [Timbarra, E of Tenterfield, 29°01'S 152°13'E], C. Stuart s.n. (lectotype, here designated, NSW 377539; isolectotypes MEL 270372, MEL 270373); Marengenburg, Braidwood, W. Baeuerlen s.n., ix.1890 (syntype NSW 385530); Braidwood District, W. Baeuerlen s.n., ix.1884 (possible isosyntype MEL 251075); Braidwood District, W. Baeuerlen s.n., xii.1884 (possible isosyntype MEL 270174); Braidwood, N.S.W., W. Baeuerlen s.n. (isosyntype K *n.v.*, photograph AD 99548104); Clyde Mountain, near Nelligen [35°33'S 149°57'E], J.L. Boorman s.n., iii.1909 (syntype NSW 385289); Clyde Mountain or Sugarloaf Mountain, J.L. Boorman s.n., ix.1915 (possible syntype NSW 385321); Belmore Falls, W. Forsythe (syntype ? NSW *n.v.*); Menangle, Mr Harper s.n., viii.1894 (syntype NSW 385576); Flinder’s Island, Gulliver (syntype ? NSW *n.v.*).

*Boronia anemonifolia* ssp. B (Wilson’s Promontory) *sensu* Ross (1996, p. 129).

*Illustrations:* N.C.W. Beadle and L.D. Beadle, *Students Flora of North Eastern New South Wales Part IV*, 554, Fig. 243B (1980); W.M. Curtis, *The Student’s Flora of Tasmania*, 105 (1975); M. Cameron, *Guide to Flowers and Plants of Tasmania*, 110 (1981).

*Shrub* to 1.5(–2.5) m tall. Branches glabrous or pubescent between decurrent leaf bases or rarely around entire stem (Sensation Gorge, Tas.), leaves prominently glandular, glabrous or glabrescent. *Leaves* 3–5-foliolate or bipinnate, the leaf in outline 13–25(–35) mm long 9–25(–30) mm wide; petiole 5–9(–16) mm long; leaflets simple, flattened or



conduplicate, entire or tridentate, broad-cuneate to oblanceolate, 3–8(–13) mm long, 1–4 mm wide, terminal leaflets usually shorter than lateral leaflets. *Inflorescences* (1–)3–6(–9+)-flowered; peduncle 2–10 mm long; prophylls glabrous, simple, linear, 0.5–1.5(–2.5) mm long; anthopodium 1.5–4(–6) mm long. *Sepals* glabrous, 1–2 mm long, 0.8–1.2 mm wide, 1/5–1/3(–1/2) of the length of the petals. *Petals* 3–5 mm long, 2.5–3 mm wide, caducous, sometimes latel; abaxial surface glabrous or glabrescent.

*Selected specimens examined* (of c. 200 collections): **QUEENSLAND**: About 1 km ENE of Gambubal Forest Station, E of Warwick, 28°14'S 152°23'E, A.R. Bean 10980 6.x.1996 (BRI n.v., NSW n.v., MEL); Paddy's Knob, Condamine Gorge, Lot 13, Parish of Emuval, 28°17'S 152°22'E, K. Sparshott KS45 & P. Sparshott, 9.iii.1993 (BRI); Mt Mitchell [possibly 28°04'S 152°23'E], anon. (MEL); **NEW SOUTH WALES**: On slope above Boonoo Boonoo River, c. 100 m upstream from Boonoo Boonoo falls, 28°48'S 152°10'E, R.G. Coveny 16565 & A.J. Whalen, 14.x.1993 (BRI, CANB, NSW, NBG n.v., P n.v., NY n.v., CHR n.v.); Hill c. 1.8 km NNE of Mt Spirabo, 29°20'00"S 152°05'05"E, P.G. Neish 31 M.F. Duretto & I Thompson, 26.x.1995 (MEL); Pheasant Mtn, 2 km E of Backwater on Paddy's Gully Rd, 30°03'S 151°55'E, J.B. Williams s.n., 30.x.1965 (NE 49121, NSW); Mt Currockbilly, Budawang Range, Southern Tablelands, 35°25'S 150°02'E, A. Sikkas and I.R. Telford BR405, 7.xii.1973 (CANB, NSW); 4.4 km west of bridge at Numeralla, then 100 m south of road, 36°11'S 149°18'E, J.D. Briggs 1885, 15.vi.1985 (BRI, CANB, MEL); 6.2 km SW of Bronte trig. and 6.6 km E of Bemboka Peak, 36°36'10"S 149°42'30"E, D.E. Albrecht 2953, 4.xi.1986 (CANB, MEL); The Pinnacles, Ben Boyd NP, 36°50'30"S 149°55'20"E, D.E. Albrecht 2282, 10.xii.1985 (MEL, NSW); **VICTORIA**: Corner Inlet, Sunday Island, C. I. Skewes s.n., 2–6.ix.1952 (AD, CANB, MEL); Snake Island, Corner Inlet on NW edge of "The Gulf", 3.25 miles [c. 5.2 km] WSW of Sunday Island, C.N. Rossiter s.n., 14.vi.1965 (MEL 516718); Port Arlington, Dickinson s.n., 1870 (MEL); **TASMANIA**: track to Seal Rocks, King Island, 40°06'S 143°58'E, M.I.H. Brooker 5855, 3.iv.1978 (CANB, HO); Fergusons Gully, Flinders Island, 40°11'S 148°04'E, P.J. Cullen s.n., 21.ix.1990 (HO 126142); Burgess Cove, Rocky Cape, 40°52'S 145°30'E, P. Collier 1126, 11.i.1986 (HO); Mt Roland, 41°28'S 146°16'E, D.A. & A.V. Ratkowsky 1308, 27.x.1974 (HO); Sensation Gorge, 6 km W of Mole Creek, 41°33'S 146°20'E, P. Collier 5123, 12.i.1991 (HO); Sensation Gorge, c. 5 km W of Mole Creek, 41°33'S 146°20'E, P. G. Neish 57–62, M.F. Duretto & K.R. Henshall, 6.i.1996 (MEL); Cape Tourville, below the lighthouse, 42°07'S 148°22'E, J. Armstrong 879., 18.v.1976 (HO); Bluff River Gorge, 42°32'S 147°40'E, P. Collier 1553, 31.viii.1986 (HO); Midway Point, 42°48'S 147°31'E, A Moscal 8395, 3.viii.1984 (AD, HO); base of St Pauls Dome, C. Stuart s.n., xi.1848 (MEL); slope near St Pauls Dome, W.H. Archer s.n. (NSW 3855335).

*Taxonomy*: When describing *B. variabilis*, Hooker (1834) cited four specimens which he classified into three forms (see *Type citation*). Of these four collections, Hooker (1840) excludes all but the  $\beta$  form (*Gmn* 214) from *B. variabilis* indicating that he thought his  $\alpha$  and  $\gamma$  forms of *B. variabilis* were actually forms of *B. tetrandra* Labill. These specimens can be confidently placed in *B. pilosa* Labill. s. lat. which Hooker (1840) also considered to be a form of *B. tetrandra*. Following Hooker (1840) the K specimen of *Gmn* 214 is chosen as the lectotype of *B. variabilis*.

When Cheel (1928) described *B. dentigeroides* he included all mainland populations of subsp. *variabilis* in it. However, his description was preceded by a week by an account by Penfold (1928) who described the essential oils of *B. dentigeroides*. In doing so, Penfold legitimately described *B. dentigeroides*. It was obviously not Penfold's intention to formally describe this species as he gives Cheel as the authority and states that "the botany of this new species, *Boronia dentigeroides*, is fully described by its author, Mr. E. Cheel, in the current issue of the Society's Journal". Later authors have quite rightly ignored Penfold's description.

Chapman (1991) in the *Australian Plant Name Index* lists *B. anethifolia* A. Cunn. var. *variabilis* (Hook.) Benth. Benth. (1863) did not make this combination but did relegate *B. anethifolia* to varietal status under *B. anemonifolia*.

*Notes*: W.J. Hooker (1834, 1840) cited only collections from Tasmania when discussing *B. variabilis*, while J.D. Hooker's (1855) concept of *B. variabilis* included plants from New South Wales and south-eastern Australia. Later, *B. variabilis* was considered a

Tasmanian endemic (c.f. Bentham 1863; Curtis 1956) and Cheel (1928) included all mainland plants in his new species, *B. dentigeroides*, a name that never gained wide acceptance. Following Bentham (1863), Willis (1957) considered *B. variabilis* a variety of *B. anemonifolia* and noted that the two varieties were "grading imperceptibly on the islands of Bass Strait into the *dentigeroides* form of *B. anemonifolia*." Curtis (1975) included *B. variabilis* in synonymy under *B. anemonifolia* and stated that "the species is polymorphic."

Mainland populations of subsp. *variabilis* have 3–5-foliolate or bipinnate leaves and leaflets usually with rounded tridentations at the apex (Fig. 11). Plants from Tasmania have 3–7-foliolate leaves and often quite narrow leaflets that are entire and sometimes recurved (Fig. 1H). These two forms grade into each other, but are united by the presence of very short sepals, short prophylls, usually glabrous leaves and pubescence on stems being confined to between the decurrent leaf bases.

Specimens of subsp. *variabilis* from St Paul's Dome in the north-west of the island (eg. *Stuart s.n.*, xi.1848, MEL 275677; *Archer s.n.*, NSW 385335) resemble subsp. *anemonifolia* in some respects. The long prophylls, long sepals, and persistent petals are characteristic of subsp. *anemonifolia*, but the glabrous, wider leaves and numerous flowers resemble that of subsp. *variabilis*. These specimens are here treated to be subsp. *variabilis*.

The small population of plants at Sensation Gorge (Tasmania; *Collier 5123*, *Neish 57-62*) are notable in being pubescent over the entire stem, rather than just between the decurrent leaf bases, and in having glabrescent leaves. Subspecies *variabilis* is known from south-eastern Queensland from collections near Warwick (*A.R. Beau 10980*, *Sparshott 45*). The *Sparshott 45* collection from Paddys Knob is notable for its slightly pubescent foliage. No other specimens have been recorded from Queensland except for a collection labelled only as Mount Mitchell (MEL 275678) which may be near Toowoomba.

*Boronia anemonifolia* subsp. *variabilis* differs from subsp. *anemonifolia* by having entire, flattened and usually glabrous leaflets, caducous petals, minute prophylls and smaller, but more numerous flowers, and from subsp. *wadbilligensis* by the smaller prophylls and glabrous to glabrescent leaves (Figs 1G–I).

**Distribution and ecology:** *Boronia anemonifolia* subsp. *variabilis* is found in south-eastern Queensland, the Northern, Central and Southern Tablelands and Central and South Coast of New South Wales, on the Bass Strait Islands, across northern Tasmania and on the hillsides around Hobart (Fig. 2). In Victoria, the subspecies is known only from Snake and Sunday Islands north of Wilsons Promontory and an 1870 collection from Portarlington on the Bellarine Peninsula. This area has been heavily degraded since settlement and recent searches in the immediate vicinity of Portarlington have failed to locate any plants of *B. anemonifolia*. *Boronia anemonifolia* subsp. *variabilis* is found in heath, open woodland or open forest on sandy and rocky soils sometimes on or near sandstone or granite outcrops.

**Conservation status:** A common subspecies that is adequately represented in reserves over its full range.

**Etymology:** The subspecific epithet refers to the variable nature of the foliage which can be trifoliolate, pinnate or bipinnate.

**2. *Boronia rigens*** Cheel, *J. & Proc. Roy. Soc. New S.Wales* 62: 297 (1929), a nom. et stat. nov. for *Boronia polygalifolia* Sm. var. *robusta* Benth., *Fl. aust.* 1: 321 (1863). *Type citation*: "Port Jackson, Sieber, n. 283; Blue Mountains, A. Cunningham; Moreton Island, F. Mueller." *Type*: New Holland, Sieber Fl. Novae holl. 283 (lectotype, here designated, K n.v., cibachrome MEL 2041262; isolectotypes MEL 257414, MEL 62147); Moreton Island [label locality information probably incorrect], F. Mueller s.n., viii.1855 (syntypes MEL 257415, MEL 257416); Blue Mountains, A. Cunningham (syntype ? K n.v.).

*Illustrations:* A. Fairley and P. Moore, *Native plants of the Sydney District*, 235, t. 816 (1989); P.H. Weston and M.F. Porteners, *Fl. New South Wales* 2: 230 (1991).

Prostrate to erect *shrub* to 30 cm tall and wide, the branches terete with moderate cork development on older branches; the stems and leaves not obviously glandular to slightly glandular; the whole plant glabrescent to pubescent, with hair density greatest between decurrent leaf bases on stems, leaves glabrescent or sparsely to moderately pilose; all hairs simple, erect, straight, to 1 mm long. *Leaves* smooth, 3(–5–7)-foliolate, rarely bipinnate, the leaf in outline 4–10(–12) mm long, 4–12 mm wide; petiole 1.5–5 mm long; rachis segments 1–3 mm long; leaflets linear to narrow elliptic, plane to carinate, concolourous, dorsiventral, (2–)4–8(–12) mm long, (0.5–)1–2 mm wide, lamina dotted with small sunken glands, hairs often concentrated along abaxial midrib, tip acute, midrib raised abaxially and distinctly red or brown. spongy mesophyll continuous under midvein, cell layer immediately above abaxial epidermis and below the midvein with secondary thickening. *Inflorescence* axillary, 1–3-flowered, glabrous or sparsely to moderately dense pilose; peduncle 0.5–2 mm long; prophylls unifoliate, 0.5–1.5 mm long; metaxephylls to 1.5 mm long, sometimes absent; anthopodium 0.5–1.5 mm long. *Sepals* broad ovate to deltate, imbricate in bud, persistent with mature fruit, 1.2–2.0 mm long, 0.5–1.2 mm wide, c. 1/2 length of petals, tip acute; adaxial surface and margin covered in short woolly hairs that are c. 0.2 mm long, becoming glabrous towards base; abaxial surface glabrous or sparsely to moderately pilose, hairs concentrated along the midrib. *Petals* white or pink, imbricate in bud, 2.5–3.5 mm long, 1.0–2.5 mm wide, glabrous or margins sparsely ciliate, persistent with mature fruit, glands often concentrated along midrib, midvein not raised on the abaxial surface, tip with a small but distinct incurved hook. *Stamens* erect, 8, all fertile; filaments gradually tapering to anther connective, pilose on margins below the slightly glandular, obtuse tip; antesealous filaments c. 1.5 mm long; antepetalous filaments 1.0–1.2 mm long; anthers attached sub-apically on the filament, anther-connective maroon; anther-apiculus prominent, glabrous. Disc entire, entirely within staminal whorl, glabrous. *Ovary* glabrous, or with a few hairs between carpels; style pilose at base, or whole style pilose; stigma rounded, as wide or slightly wider than style. *Cocci* glabrous or sparsely pubescent, 2.5–3.5 mm long, 1.5–2.0 mm wide. Seeds elliptical in outline, 2–4 mm long, 1–2 mm wide, black or black-brown, dull, slightly tuberculate, microscopic wax crystals on surface between tuberculae.

*Selected specimens examined (of c. 100 collections):* NEW SOUTH WALES: Head of Coricudgy Ck, 3 miles [c. 4.8 km] N of Mt Coricudgy, L.A.S. Johnson s.n., 30.viii.1951 (NSW 17273); 1 mile east of Currant Mountain Gap, Rylstone District, B.G. Briggs s.n., 6.viii.1961 (NSW 385503); Bunboori Ck, via Waratah Ridge, Blue Mountains NP, 33°25'S 150°17'E, P. Hind 6340, 11.iii.1991 (NSW); Mount Banks, on North slope, 33°36'S 150°21'E, D. Benson 2319 & D. Keith, 15.ii.1985 (NSW); La Perouse, 33°59'S 151°14'E, R. Coveny 11199, 28.vii.1982 (CANB); 3.8 km along Tevotts Road, c. 6 km SW of Bundanoon, 34°41'S 150°18'E, P. Ollerenshaw 1740, 28.vii.1985 (CANB); Northern Budawang Range, Wog Wog Creek - Corang Trig track, 35°27'S 150°05'E, I.R. Telford 9549, 15.viii.1976 (CANB); Endeavour Reserve, around base of communication tower, c. 1 km South of Bombala, 36°55'S 149°15'E, P.G. Neish 74 & A.J. Vadala, 10.iv.1996 (MEL).

*Notes:* Cheel's concept of *B. rigens* was based on discordant elements that included specimens of *B. uana* from South Australia (Mt. Lofty Range) and Victoria. Although superficially similar to *B. uana* var. *uana*, *B. rigens* can be distinguished by leaflets with distinctly raised midribs on the abaxial surface that are usually red and darker than the rest of the leaf. This dark colouration is due to large pigment-filled cells in the midrib.

*Distribution and ecology:* *Boronia rigens* is found between Bombala and Rylstone on the Southern and Central Tablelands and in coastal areas around Sydney, New South Wales (Fig. 2). It is usually found in woodland or heath on sandy or stony soils associated with sandstone.

One of the type collections of *B. polygalifolia* var. *robusta* is a specimen collected by



Ferdinand Mueller which supposedly came from Moreton Island near Brisbane, south-eastern Queensland. No other collections of *B. rigens* have been made north of Rylstone and it is assumed that Mueller's specimens were mislabelled.

*Conservation status:* Though found over a limited area, *B. rigens* is well represented in National Parks and is not considered to be rare or threatened.

*Etymology:* The specific epithet is derived from the Latin, *rigens*, for stiff or rigid and is possibly referring to the stiff or rigid habit of the plant as compared to the lax *B. polygalifolia* and *B. nana*.

## Acknowledgements

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## The lichens of *Nothofagus cunninghamii*-dominated rainforests and *Acacia melanoxylon*-dominated forests in the Otways, Victoria.

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### Abstract

Lichens occurring in rainforests dominated by *Nothofagus cunninghamii* (Hook.) Oerst. and in forests dominated by *Acacia melanoxylon* R. Br. were examined in the Otway Ranges, southwest Victoria. A total of 110 species were recorded, 93 occurred in *N. cunninghamii* rainforests and 67 in *A. melanoxylon* forests. Fifty of these species were common to both forest types. In total, 17 lichen species are newly reported for Victoria.

### Introduction

The Otway Ranges are approximately 200 km southwest of Melbourne, Victoria (D.N.R.E. 1996). Calder (1990) described the region as an island, with Bass Strait to the south and the vast basalt plains to the north effectively isolating the area. There are no comparable regions closer than 400 km away (Calder 1990). The Otway Ranges extend approximately 80 km, and contain a wide variety of forest types including examples of heathlands, coastal vegetation, wet mountain forests and cool temperate rainforest (D.N.R.E. 1996).

The Otways have a temperate climate. Most rain falls between May and September, with the mean annual rainfall varying between 1750 to 2000 mm (Brinkman & Farrell 1990). Mean maximum temperatures range from 20°C on the coast to 27°C inland in the warmest months, January and February (Brinkman & Farrell 1990). The coldest months see average minimums of 3 to 4°C (Brinkman & Farrell 1990).

There is little published information on the lichen flora of the Otways region, although historically the region has attracted some attention from past collectors, for example, R. Filson in 1963–4, J.H. Willis in 1955 and 1963 and A.C. Beaglehole in 1953. Indeed, there are comparatively few studies on lichens in Victorian rainforests. Louwhoff (1995) examined the lichen floristics of Mt. Donna Buang Scenic Reserve, which included some small pockets of rainforest, and Wedin (1995), in his review of the lichen family Sphaerophoraceae in the southern hemisphere, examined the genera *Bunodophoron* A. Massal. and *Lefidium* Wedin from Victorian rainforest. Recently, a revision of the lichen genus *Usnea* Dill. ex Adans. included species found in rainforests in Victoria (Stevens 1999).

Cool temperate rainforests are cited as one of the most important vegetation communities in the Otways (D.N.R.E. 1996) and are dominated by *Nothofagus cunninghamii* (Hook.) Oerst. Many Victorian rainforests are co-dominated by *N. cunninghamii* and *Atherosperma moschatum* Labill., however, the latter species appears to be absent from the Otways (Busby & Brown 1994; Peel 1999), and is apparently being replaced by *Hedycarya angustifolia* A. Cunn. for the most part, but also in part by *Pittosporum bicolor* Hook., *Olearia argophylla* (Labill.) Benth. and *Acacia melanoxylon* R.Br. *Dicksonia antarctica* Labill. is always present as an understorey along with ground ferns such as *Blechnum wattsii* Tindale and/or *Polystichum proliferum* (R. Br.) Presl. The Otways *N. cunninghamii*-dominated rainforests are classified as "callidendrous rainforest" (after Jarman *et al.* 1991) or "Otways cool temperate rainforest" (after Peel 1999).

*Acacia melanoxylon* is a fast growing species (Floyd 1989) that forms almost pure stands in the Otways. The species is dominant in areas of past disturbance and frequent

fire, which tends to favor the establishment of *Acacia* species (Busby & Brown 1994). Physiognomically, these almost pure stands of *A. melanoxylon* might be classified as either callidendrous or thamnic rainforests (after Jarman *et al.* 1991) as they have a structural resemblance to true rainforest (closed canopies, multi-strata vegetation, ferny understorey and high dominance of epiphytes). However, they are floristically not considered rainforests unless there is significant co-dominance by *N. cunninghamii* or other recognised rainforest trees (D.C.F.L. 1987; Peel 1999). These forests are considered 'tall open forests' by Ashton and Attiwill (1994). Other associated species include *Neumatolepis squamea* (Labill.) Paul. G. Wilson, *Coprosma quadrifida* (Labill.) Robinson, *Olearia argophylla* and *Pomaderris aspera* Sieb. ex DC. *Dicksouia antarctica* and *B. wattsi* are often present as understorey species.

This paper examines some of the similarities and differences in lichen composition between rainforests dominated by *Nothofagus cunninghamii* (Hook.) Oerst. and the structurally similar tall open forests dominated by *Acacia melanoxylon* R. Br. in the Otways, Victoria. The study forms part of a much larger, ongoing investigation examining the lichen communities of cool temperate rainforest throughout Victoria.

## Methods

A total of 20 randomly selected quadrats were sampled, 10 in rainforests dominated by *Nothofagus cunninghamii* and 10 in forests dominated by *Acacia melanoxylon*.

Due to the very limited extent of rainforest in Victoria, the more traditional map-grid method of randomly selecting sites was not appropriate. Victorian rainforests occur as small pockets in moist gullies and along creeks and rivers (Busby & Brown 1994; D.C.F.L. 1987). Those of the Otways are no exception. Methods using larger scale grids would certainly miss most of these pockets. Instead, potential sites of both *N. cunninghamii*-dominated rainforest and, for consistency, *A. melanoxylon*-dominated forests were located through study of maps and by field surveys. Appropriate sites were listed and a computer-generated random number table was used to select actual study sites.

Quadrats measuring 20m  $\times$  20m (after Louwhoff 1992, 1995) were placed in the approximate centre of the selected forest pockets, where edge effect was considered minimal.

Five trees of each species present in four size classes (Table 1) were sampled where they were present in the quadrat. Different size classes of trees represent different ages and, hence, have varying bark characteristics. This factor is known to influence lichen floristics (Adams & Risser 1971; Griffin & Conran 1994; Kantvilas 1990), so each size class must be examined to obtain an accurate representation of the lichen flora present in the forest pocket under investigation. An analysis of lichen variation between size classes was not undertaken as this would require a much larger sample size than that obtained.

Lichen species and percent cover-abundance were recorded up to a height of 2 metres,

**Table 1.** Size classes used for the major tree species in *Nothofagus cunninghamii*-dominated rainforests and *Acacia melanoxylon*-dominated forests in Victoria.

Size class	Radius at chest height (cm)
Small	<5
Medium	5–10
Large	10–20
Extra Large	20+

this being the practical limit of accessibility. Recently fallen branches and sticks were collected from the forest floor in each quadrat as a representation of what was present in the canopy (Jarman & Kantvilas 1995a).

Nomenclature follows Filson (1996), *Flora of Australia* Volumes 54 and 55 (1992 and 1994 respectively), Wedin (1995) for the genera *Bunodophoron* and *Lefidium* and Stevens (1999) for the genus *Usnea*. Distinct lichen species not able to be matched against available literature were assigned "sp. 1" etc.

A 2-dimensional Non-metric Multidimensional Scaling (NMDS) ordination for the average cover of each lichen species in the 20 quadrats was performed using CLUSTER, MDS and CONPLOT in the statistical package PRIMER (Plymouth Routines in Multivariate Ecological Research). NMDS constructs a configuration of the samples, which attempts to satisfy all the conditions imposed by the rank similarity matrix (Clarke & Warwick 1994). Bray-Curtis similarity matrix was used, which is appropriate for delineating groups of sites with distinct community structure and patterns of abundance (Clarke & Warwick 1994). The data were given 4th root transformation in order to evenly weight both the dominant species and the rare species (Clarke & Warwick 1994). A dendrogram results from the CLUSTER option of PRIMER, and is presented as further explanation of the relationships between the similarities of quadrats.

# Results

In total, 495 trees, representing 10 different vascular species, were examined (Table 2). A total of 110 lichen species were recorded, 93 from rainforests dominated by *N. cunninghamii* and 67 from forests dominated by *A. melanoxylon*. Fifty species were common to both forest types (Appendix 1).

Of the 93 lichen species occurring in *N. cunninghamii* rainforests, 66 were recorded in the canopy and 38 in the lower trunk region. Thirteen species were found in both the canopy and lower trunk regions (Fig. 1). Similarly, the canopy of *A. melanoxylon* forests had a higher species richness than the lower trunk region with 43 and 35 species respectively and 12 species common to both. The lower trunk region of both forest types appeared to be comparable in terms of lichen species richness over the 20 quadrats examined.

**Table 2.** Number of trees of each species sampled.

Tree species	Total sampled	<i>Nothofagus</i> rainforest	<i>Acacia</i> forest
<i>Nothofagus cunninghamii</i>	113	102	11
<i>Hedycarya augustifolia</i>	98	45	53
<i>Acacia melanoxylon</i>	91	7	84
<i>Dicksonia antarctica</i>	68	43	25
<i>Coprosma quadrifida</i>	53	19	34
<i>Pittosporum bicolor</i>	27	11	16
<i>Olearia argophylla</i>	19	9	10
<i>Nematolepis squamea</i>	13	0	13
<i>Pouaderris aspera</i>	11	0	11
<i>Cyathea australis</i>	2	0	2
<b>Total:</b>	<b>495</b>	<b>236</b>	<b>259</b>



**Figure 1.** Lichen species-richness of the lower trunk and canopy, showing overlap of species common to both.

In total, 30 families were represented in the forests studied, 29 occurred in *N. cunninghamii* rainforests and 24 occurred in *A. melanoxylon* forests. All families recorded in *A. melanoxylon* forests were found in *N. cunninghamii* rainforests, with the exception of the Ramalinaceae. Six families were exclusive to *N. cunninghamii* rainforest: Arthoniaceae, Chrysothricaceae, Coccotremataceae, Lecanactidaceae, Nephromataceae and Teloschistaceae. In all cases, representatives from these families were not recorded frequently in the study areas, therefore, there may be insufficient data from which to draw conclusions.

Ten families were well represented in *N. cunninghamii* rainforests, with four or more species being recorded for each (Table 3). In *A. melanoxylon* forests, six families were recorded with more than four species each. In many cases, these families were represented by only one genus, for example, the Thelotremataceae by the genus *Thelotrema* Ach., the Pertusariaceae by *Pertusaria* DC. and the Usneaceae by *Usnea* Dill. ex Adans. The families Cladoniaceae, Lobariaceae, Pertusariaceae, Sphaerophoraceae and Thelotremataceae appear to be important groups for *N. cunninghamii* rainforests as they have large numbers of representative species, and were rarely recorded in *A. melanoxylon* forests (Table 3). Similarly the Collemataceae appears to be an important family in the *A. melanoxylon* forests.

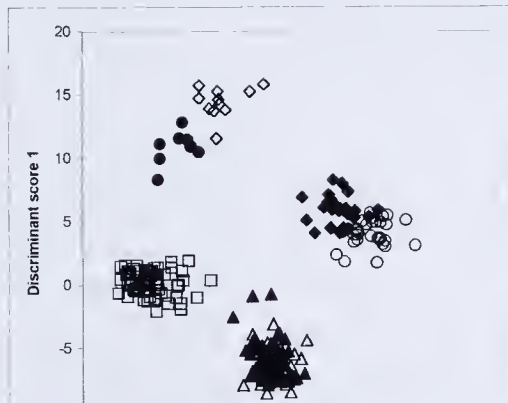
**Table 3.** Commonly represented families in *Nothofagus cunninghamii*-dominated rainforests and *Acacia melanoxylon*-dominated forests in the Otways.

Family	<i>Nothofagus</i> -dominated		<i>Acacia</i> -dominated	
	No. Genera	No. Species	No. Genera	No. Species
Cladoniaceae	2	4		
Collemataceae			2	4
Hypogymniaceae	2	8	2	5
Lecideaceae	4	5	3	5
Lobariaceae	1	7		
Pannariaceae	1	5	2	4
Parmeliaceae	6	12	5	8
Pertusariaceae	1	6		
Sphaerophoraceae	2	6		
Thelotremataceae	1	4		
Usneaceae	1	5	1	7



Canopy species were included in the above figures, however, due to the haphazard nature of collecting lichens from the canopy, these data were not included in the following analyses. It is possible to indicate which species are present in the canopy, but the absence of species could just be a reflection of the sampling procedure.

The number of species per quadrat ranged from as low as two species in *A. melanoxylon* forest, and up to 20 species in *N. cunninghamii* rainforest (Fig. 2). On average, *N. cunninghamii* rainforests supported a higher species richness (mean of 12.8 species) than *A. melanoxylon* forests (mean of 8.7 species), however, an independent samples *t* test revealed that this difference was not significant ( $p = 0.085$ ).



**Figure 2.** Species richness per quadrat in the two forest types. A *t* test on the difference between the means was not significant with  $p = 0.085$ .

On consideration of the common species from the two forest types (that is species occurring in six or more of the ten quadrats), there appears to be a distinct flora for each forest type, with two species, *Lepraria* sp. and *Thelotrema lepadinum* (Ach.) Ach. being common to both (Table 4). Three species, *Bunodophoron australe* (Laurer) A. Massal, *Metus conglomeratus* (F. Wilson) D.J. Galloway & P. James and *Pyrenula nitida* (Weig.)

**Table 4.** Comparison of common species (occurring in six or more of the ten quadrats) in the lower trunk region of *Nothofagus cunninghamii*-dominated rainforests and *Acacia melanoxylon*-dominated forests.

<i>Nothofagus cunninghamii</i> rainforest	<i>Acacia melanoxylon</i> forest
<i>Bunodophoron australe</i>	
<i>Bunodophoron murrayi</i>	
<i>Cladia aggregata</i>	
<i>Metus conglomeratus</i>	
<i>Pseudocyphellaria dissimilis</i>	
<i>Pseudocyphellaria glabra</i>	
<i>Pyrenula nitida</i>	
<i>Thelotrema subdenticulatum</i>	
<i>Lepraria</i> sp.	<i>Lepraria</i> sp.
<i>Thelotrema lepadinum</i>	<i>Thelotrema lepadinum</i>
	<i>Bacidia buchananii</i>
	<i>Leptogium victoriae</i>
<b>10 species</b>	<b>4 species</b>



**Table 5.** Comparison of common species (occurring in six or more of the ten quadrats) from the canopy of *Nothofagus cunninghamii*-dominated rainforests and *Acacia melanoxylon*-dominated forests.

<i>Nothofagus cunninghamii</i> rainforest	<i>Acacia melanoxylon</i> forest
<i>Coccotrema cucurbitula</i>	
<i>Menegazzia myriotrema</i>	
<i>Menegazzia</i> sp. 1	
<i>Pertusaria novaezealandiae</i>	
<i>Sarrameana tasmanica</i>	
<i>Thelotrema</i> sp. B	
<i>Maronea constans</i>	<i>Maronea constans</i>
<i>Megalania grossa</i>	<i>Megalania grossa</i>
<i>Parmelia tenuirima</i>	<i>Parmelia tenuirima</i>
<i>Thelotrema lepadinum</i>	<i>Thelotrema lepadinum</i>
	<i>Hypogymnia mundata</i>
	<i>Normandina pulchella</i>
	<i>Parmelia quercina</i>
	<i>Pertusaria gibberosa</i>
	<i>Pyrrhospora laeta</i>
	<i>Tephromela atra</i>
<b>10 species</b>	<b>11 species</b>

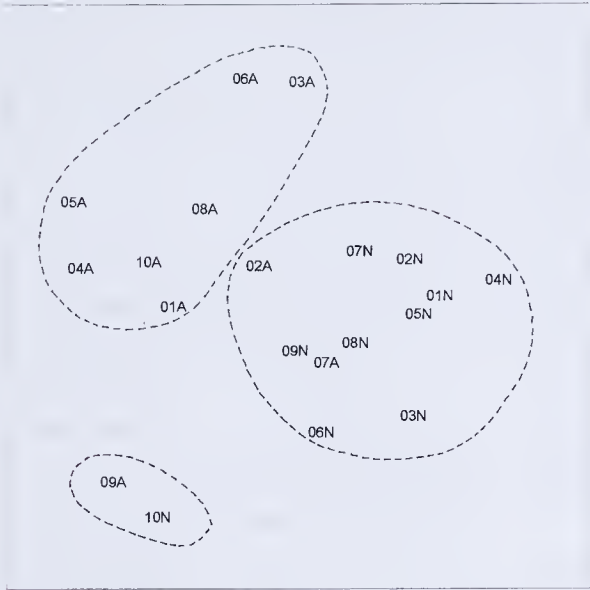
Ach., were not recorded in *A. melanoxylon* forests. In the canopy (Table 5), differences in species composition also can be seen, with four species, *Maronea constans* (Nyl.) Hepp., *Megalania grossa* (Pers. ex. Nyl.) Hafellner, *Parmelia tenuirima* Hook. f. & Taylor and *T. lepadinum* being common to both forest types.

A NMDS ordination configuration of average cover abundance of lichen species in each quadrat revealed two groups of quadrats with 2 outlier quadrats (Fig. 3). The dotted lines enclose groups of sites with a similarity of 32 percent, as shown in the dendrogram (Fig. 4). There appeared to be a lichen flora that was characteristic of *N. cunninghamii* rainforest and a lichen flora characteristic of *A. melanoxylon* forest as both forests clustered separately. The exceptions were quadrat numbers 07A and 02A which showed a high similarity to the quadrats dominated by *N. cunninghamii*. The dendrogram (Fig. 4) clustered these two quadrats with the *N. cunninghamii* forests at 55 and 50 percent similarity, respectively. Quadrat 07A was dominated by *A. melanoxylon*, but had a subdominant canopy of *N. cunninghamii*. Quadrat 02A appeared to have a fairly common collection of lichen species, with no rare or unusual species, which may contribute to its similarity to *N. cunninghamii* forests. Indeed, this quadrat may be clustered arbitrarily with the other *A. melanoxylon* forests on the NMDS (Fig. 3). The outliers 09A and 10N recorded the lowest number of species for their respective forest types. A NMDS ordination was also done for presence/absence data and lichen cover per area of tree sampled. Results were essentially the same with only minor variations in distance configuration.

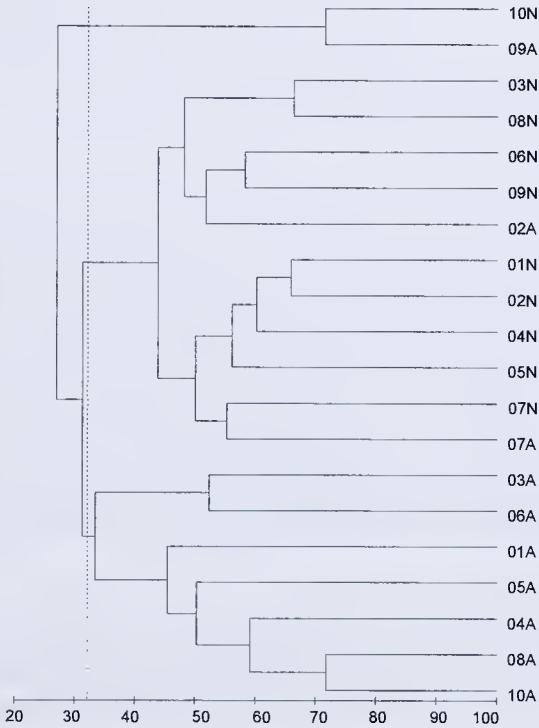
### New Records

All lichen species have previously been found in Australia, but a total of 17 new records for Victoria were recorded during this study (Table 6). Of these, *Bimodophoron murrayi* (Ohlsson) Wedin, *Coccotrema cucurbitula* (Mont.) Mull. Arg., *Graphis insidiosa* (C.

**Figure 3.** Mean cover of lichen species. NMDS of 20 sites based on 4<sup>th</sup> root transformed abundances and Bray-Curtis similarities (Stress = 0.14). N = quadrats dominated by *Nothofagus cunninghamii*; A = quadrats dominated by *Acacia melanoxylon*.



**Figure 4.** Mean cover of lichen species. Dendrogram of 20 quadrats using average clustering from Bray-Curtis similarities on 4<sup>th</sup> root transformed cover abundance data.



**Table 6.** Lichen species newly recorded for Victoria.

Species	Herbarium No.*	Spp. description ref.
<i>Bacidia laurocerasi</i>	MEL; SF 120	Galloway 1985
<i>Bunodophoron murrayi</i>	MEL 2085466; SF110	Galloway 1985; Wedin 1995 (as <i>Sphaerophorus murrayi</i> )
<i>Cliostomum griffithii</i>	MEL 2085462; SF108/109	Galloway 1985
<i>Coccotrema cucurbitula</i>	MEL 2085468	Galloway 1985; Kantvilas 1990a
<i>Graphis insidiosa</i>	MEL 2085463; SF119	Galloway 1985; Kantvilas & James 1991
<i>Lecidea immarginata</i>	MEL, SF123	Kantvilas & James 1991
<i>Lepraria lobificans</i>	MEL 2085461; SF142/157	Kantvilas & James 1991
<i>Menegazzia eperforata</i>	MEL 2085469; SF158	Flora of Australia 1992
<i>Micarea prasina</i>	MEL 2085467	Coppins 1983
<i>Parmelia protosulcata</i>	MEL 2085464	Flora of Australia 1994
<i>Parmotrema robustum</i>	MEL 2060624; SF116 (from W. Prom) Flora of Australia 1994	
<i>Phaeographis exaltata</i>	MEL 2085465; SF117/118	Galloway 1985; Kantvilas & James 1991
<i>Phlyctis subuncinata</i>	MEL 2085470	Galloway 1985; Kantvilas & James 1991
<i>Sarrameana albidoplumbea</i>	MEL 2085471	Kantvilas & Vezda 1995
<i>Usnea oncodes</i>	MEL 2085460; SF144/150	Stevens 1999
<i>Usnea pycnoclada</i>	SF149	Stevens 1999
<i>Usnea xanthopoga</i>	MEL 2085472; SF151	Stevens 1999

\* MEL = Melbourne Herbarium, Royal Botanic Gardens, South Yarra

SF = Personal herbarium of Sharon Ford

Knight & Mitt.) Hook. f., *Lecidea immarginata* R. Br. ex Cromb., *Menegazzia eperforata* P. James & D.J. Galloway, *Micarea prasina* Fr., *Parmelia protosulcata* Hale, *Usnea pycnoclada* Vainio and *U. xanthopoga* Nyl. are not surprising additions to Victoria's lichen flora as they are currently known from Tasmania and New South Wales. These records simply fill in the previous disjunct distribution. *Cliostomum griffithii* (Sm.) Coppins, *Lepraria lobificans* Nyl., *Phaeographis exaltata* (Mont. & v.d. Bosch) Mull. Arg., *Phlyctis subuncinata* Stirton, *Sarrameana albidoplumbea* (Hook. f. & Taylor) Farkas and *Usnea oncodes* Stirton are new for the mainland and *Bacidia laurocerasi* (Delise ex Duby) Zahlbr. and *Parmotrema robustum* (Degel.) Hale have their southern most record in the Otways. *Menegazzia eperforata* and *P. robustum* were recently reported from the rainforests at Wilsons Promontory by one of the authors (Ford & May, 1998), however, no formal publication of these records was made at the time.

## Discussion

Currently, the number of macrolichen species in Tasmanian rainforests stands at 355 species, 200 macrolichens and 155 crustose lichens (Jarman & Kantvilas 1995a). The total number of lichen species currently known for Victorian rainforests is 149 species,

with 94 macrolichens and 54 microlichens (compiled from Ford unpubl.; Ford & May 1998; Louwhoff 1995). Victorian rainforest lichen figures are projected to increase considerably as more work is completed. The lichens of Tasmanian rainforests and wet sclerophyll forests have received much attention in the past decade (Brown *et al.* 1994; Jarman & Kantvilas 1994; Jarman & Kantvilas 1995a; Jarman & Kantvilas 1995b; Kantvilas 1990; Kantvilas 1995; Kantvilas & James 1991; Kantvilas & Jarman 1991; Kantvilas & Jarman 1993), allowing for comparison of the lichen flora of the Otways with published lists for Tasmanian forests.

A large proportion of the lichens found during this study may be considered "ubiquitous wet forest" species (Kantvilas & Jarman 1993). Of the 31 lichen species listed as ubiquitous by Kantvilas & Jarman (1993, p. 219), 19 were recorded from the Otways. Of these, all 19 species were found in *N. cunninghamii* rainforest, and 14 species were found in *A. melanoxylon* forest. Common examples include: *Bacidia buchananii* (Stirt.) Hellb., *Cladia aggregata* (Sw.) Nyl., *Parmelia tenuirima* Hook f. & Taylor, *Psoroma microphyllizans* (Nyl.) D.J. Galloway and *Pseudocyphellaria glabra* (Hook f. & Taylor) C.W. Dodge. Of the 26 "typical rainforest species" listed by Jarman and Kantvilas (1993), seven were found in this study. All seven species were recorded in *N. cunninghamii* rainforest, and four species (*Sarrameana albidoplumbea* (Hook f. & Taylor) Farkas (syn. *Bacidia albidoplumbea*), *Micarea prasina* Fr., *Thelotrema lepadinum* (Ach.) Ach. and *Usnea oncodes* Stirton) were found in the tall open forests dominated by *A. melanoxylon*. Seven out of 34 "non-rainforest species" (Kantvilas & Jarman 1993), or species that generally characterise sclerophyll forest, were also found, five in *N. cunninghamii* rainforest and 6 in *A. melanoxylon* forest.

Many of the lichens recorded in this study are considered "widespread" lichens for the three Tasmanian rainforest suballiances: callidendrous, thamnisc and implicate (Jarman & Kantvilas 1995a; refer to Jarman *et al.* 1991 for rainforest descriptions). Of the 44 widespread rainforest lichens listed (Jarman & Kantvilas 1995a), 28 were found in the Otways. Twenty-five of these species were recorded from *N. cunninghamii* rainforest and 15 species from *A. melanoxylon* forest. Of the 18 species listed as being restricted to callidendrous rainforest, five species were recorded in *A. melanoxylon* forests. These were *S. albidoplumbea*, *Bunodophoron murrayi*, *Menegazzia myriotrema*, *P. tenuirima* and *Pseudocyphellaria dissimilis* (Nyl.) D.J. Galloway & P. James. These five species and an additional three species (*Arthothelium interveniens* (Nyl.) Zahlbr., *Bunodophoron ramuliferum* (I.M. Lamb) Wedin and *Lecanactis abietina* (Ach.) Korb.) were found in *N. cunninghamii* rainforest.

It was interesting to note that some typical rainforest lichen species are recorded in *A. melanoxylon*-dominated tall open forest. The observed structural similarities between *N. cunninghamii* rainforests and *A. melanoxylon* forests may lead to microclimatic correlations, explaining some of the similarity in lichen species composition. The presence of *N. cunninghamii* as a component of the canopy in some *A. melanoxylon* dominated forests also may be a contributing factor. Just as different forms of rainforest have a ubiquitous group of lichen species and a number that are characteristic of each forest type (Jarman & Kantvilas 1995a), the results suggest that *N. cunninghamii* rainforests and *A. melanoxylon* forests also have both a distinct flora and a shared flora. Seventy-nine percent of lichen families were represented in both forest types, while 45 percent of species were common to both. The remainder are divided, 39 percent of lichen species are confined to *N. cunninghamii* rainforest and 15 percent of species confined to *A. melanoxylon* forests.

In studies comparing rainforest to sclerophyll forest, rainforests consistently recorded higher species richness (Jarman & Kantvilas 1994; Kantvilas & Jarman 1993; Louwhoff 1995). However, the differences may be minimal, for example Kantvilas & Jarman (1993) recorded 79 species in disturbed rainforest in Tasmania and 72 species in surrounding sclerophyll forest, a difference of seven species. Jarman and Kantvilas (1994)



recorded 72 and 78 lichen species in two types of *Eucalyptus*-dominated sclerophyll forest, compared to 83 species in rainforest, with a minimum difference of 5 species. Louwhoff (1995) recorded 56 species in *N. cunninghamii*-dominated rainforest and 42 species in *Eucalyptus*-dominated sclerophyll forests at Mt. Donna Buang Scenic Reserve, Victoria, a difference of 14 species.

A considerably greater difference in species number was found between the two forest types considered here, when compared with similar studies comparing forest types in south-eastern Australia. Overall (canopy inclusive), a difference of 26 species was found, with higher species richness recorded in *N. cunninghamii* rainforests (93 spp. compared to 67 spp. in *A. melanoxydon* forests).

Lichenologically, cool temperate rainforests are recognised as one of the most floristically diverse forest types (Jarman & Kantvilas 1995a; 1994; Kantvilas 1990). The generally low species richness in *A. melanoxydon* tall open forests may be an indication that these forests are quite distinct from *N. cunninghamii*-dominated rainforest despite their structural similarity. However, they share a high proportion of lichen species with the *N. cunninghamii* rainforests, some of which are considered true rainforest lichen species.

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**Appendix 1.** Lichen species list for the Otway Ranges, Victoria. Presence in two forest types - *Nothofagus*-dominated rainforests and *Acacia*-dominated forests.

Species List	<i>Nothofagus</i> rainforest	<i>Acacia</i> forest
<i>Arthothelium interveniens</i> (Nyl.) Zahlbr.	+	
<i>Bacidia bichauauii</i> (Stirt.) Hellb.	+	+
<i>Bacidia laurocerasi</i> (Delise ex Duby) Zahlbr. <sup>N</sup>		+
<i>Buellia</i> sp. 1	+	
<i>Buellia</i> sp. 2	+	+
<i>Bunodophoron anstrale</i> (Laurer) A. Massal.	+	
<i>Bunodophoron insigne</i> (Laurer) Wedin	+	+
<i>Bunodophoron umrayi</i> (Ohlsson) Wedin <sup>N</sup>	+	+
<i>Bunodophoron patagonicum</i> (C.W. Dodge) Wedin	+	
<i>Bunodophoron ramuliferum</i> (I.M. Lamb) Wedin	+	
<i>Bunodophoron</i> sp.		+
<i>Caloplaca</i> sp.	+	
<i>Chrysotrix caudularis</i> (L.) J.R. Laundon	+	
<i>Cladia aggregata</i> (Sw.) Nyl.	+	+

<i>Cladonia ochrochlora</i> Florke	+	
<i>Cladonia ramulosa</i> (With.) J.R. Laundon	+	
<i>Cladonia rigida</i> (Hook f. & Taylor) Hampe	+	
<i>Cladonia subradiata</i> (Vain.) Sandst.		+
<i>Cliostomum griffithii</i> (Sm.) Coppins <sup>N</sup>	+	+
<i>Coccotrema cucurbitula</i> (Mont.) Mull. Arg. <sup>N</sup>	+	
<i>Coenogonium implexum</i> Nyl.	+	+
<i>Collema fasciculare</i> (?var. <i>microcarpum</i> ) (Mull. Arg.) Degel.		+
<i>Collema</i> cf. <i>laeve</i> Hook f. & Taylor		+
<i>Collema subconveniens</i> Nyl.	+	+
<i>Degelia gayana</i> (Mont.) Arv. & D.J. Galloway		+
<i>Dimerella lutea</i> (Dicks.) Trevis	+	+
<i>Graphis insidiosa</i> (C. Knight & Mitt.) Hook. f. <sup>N</sup>	+	
<i>Graphis tenella</i> Ach.	+	+
<i>Heterodermia hypocaesia</i> (Yasuda) Awasthi		+
<i>Hypogymnia enteromorphaeoides</i> Elix		+
<i>Hypogymnia mundata</i> (Nyl.) Oxner ex Rass.	+	+
<i>Hypogymnia subphysodes</i> (Kremp.) Filson	+	
<i>Hypogymnia</i> (cf. <i>tasmanica</i> ?)	+	
<i>Hypotrachyna sinuosa</i> (Sm.) Hale	+	
<i>Lecanactis abietina</i> (Ach.) Korb.	+	
<i>Lecidea immarginata</i> R. Br. ex Cromb. <sup>N</sup>	+	
<i>Lefidium tenerum</i> (Laurer) Wedin	+	
<i>Lepraria lobificans</i> Nyl. <sup>N</sup>	+	+
<i>Lepraria</i> sp.	+	+
<i>Leptogium victorianum</i> F. Wilson	+	+
<i>Maronea constans</i> (Nyl.) Hepp.	+	+
<i>Megalania grossa</i> (Pers. ex . Nyl.) Hafellner	+	+
<i>Menegazzia confusa</i> P. James	+	+
<i>Menegazzia eperforata</i> P.James & D.J.Galloway <sup>N</sup>	+	
<i>Menegazzia myriotrema</i> (Mull. Arg.) R. Sant.	+	+
<i>Menegazzia norstictica</i> P. James	+	
<i>Menegazzia platytrema</i> (Mull. Arg.) R. Sant.	+	+
<i>Menegazzia</i> sp. 1	+	
<i>Menegazzia subpertusa</i> P. James & D.J. Galloway		+
<i>Metus conglomeratus</i> (F. Wilson) D.J. Galloway & P. James	+	
<i>Micarea prasina</i> Fr. <sup>N</sup>	+	+
<i>Micarea</i> spp. agg.	+	
<i>Nepluroma australe</i> A. Rich	+	
<i>Normandina pulchella</i> (Borrer) Nyl.	+	+
<i>Ochrolechia</i> sp.	+	
<i>Parmelia cunninghamii</i> Cromb.	+	
<i>Parmelia protosulcata</i> Hale <sup>N</sup>	+	+
<i>Parmelia temurima</i> Hook. f. & Taylor	+	+
<i>Parmeliella nigrocincta</i> (Mont.) Mull. Arg.		+
<i>Parmelina endoleuca</i> (Taylor) Hale	+	
<i>Parmelina labrosa</i> (Zahlbr.) Elix & J.Johnst.	+	+
<i>Parmelina quercina</i> (Willd.) Hale	+	+
<i>Parmelinopsis afrorevoluta</i> (Krog & Swinscow) Elix & Hale	+	+
<i>Parmelinopsis subfatiszens</i> (Kurok.) Elix & Hale	+	+
<i>Parmotrema chinense</i> (Osbeck) Hale & Ahti	+	+
<i>Parmotrema robustum</i> (Degel.) Hale <sup>N</sup>	+	
<i>Peltigera dolichorrhiza</i> (Nyl.) Nyl.	+	+

<i>Pertusaria gibberosa</i> Mull. Arg.	+	+
<i>Pertusaria novaezelandiae</i> Szatala	+	+
<i>Pertusaria truncata</i> Kremp.	+	
<i>Pertusaria</i> sp. 1	+	+
<i>Pertusaria</i> sp. 2	+	
<i>Phaeographlis exaltata</i> (Mont. & v.d. Bosch) Mull. Arg. <sup>N</sup>	+	
<i>Phlyctis subuncinata</i> Stirton <sup>N</sup>	+	+
<i>Physcia adscendens</i> (Fr.) H. Olivier		+
<i>Pseudocyphellaria billardierei</i> (Delise) Rasanen	+	
<i>Pseudocyphellaria colensoi</i> (C. Bab. ex Hook. f.) Vain.	+	
<i>Pseudocyphellaria dissimilis</i> (Nyl.) D.J. Galloway & P. James	+	+
<i>Pseudocyphellaria glabra</i> (Hook. f. & Taylor) C.W. Dodge	+	+
<i>Pseudocyphellaria multifida</i> (Nyl.) D.J. Galloway & P. James	+	+
<i>Pseudocyphellaria rubella</i> (Hook. f. & Taylor) D.J. Galloway & P. James	+	
<i>Pseudocyphellaria</i> sp. A	+	
<i>Psoroma asperellum</i> Nyl.	+	
<i>Psoroma durietzii</i> P. James & Henssen	+	
<i>Psoroma leprolomum</i> (Nyl.) Rasanen	+	+
<i>Psoroma microphyllizans</i> (Nyl.) D.J. Galloway	+	+
<i>Psoroma</i> sp. 1	+	
<i>Punctelia borveri</i> (Sm.) Krog		+
<i>Pyrenula nitida</i> (Weig.) Ach.	+	
<i>Pyrenula</i> sp. 1	+	+
<i>Pyrrhospora laeta</i> (Stirt.) Hafellner	+	+
<i>Ramalina inflata</i> Hook. f. & Taylor		+
<i>Rauboldia brunneocarpa</i> Kantvilas & Elix	+	
<i>Rimelia reticulata</i> (Taylor) Hale & A.Fletcher	+	
<i>Sarrameana albidoplumbea</i> (Hook.f. & Taylor) Farkas <sup>N</sup>	+	+
<i>Sarrameana tasmanica</i> Vezda & Kantvilas	+	+
<i>Tephromela atra</i> (Huds.) Hafellner	+	+
<i>Thelotrema decorticans</i> Mull. Arg.	+	
<i>Thelotrema lepadinum</i> (Ach.) Ach.	+	+
<i>Thelotrema subdenticulatum</i> (Zahlbr.) G. Salisb.	+	+
<i>Thelotrema</i> sp. 1		+
<i>Thelotrema</i> sp. 2	+	+
<i>Usnea oncodeoides</i> G.N. Stevens	+	+
<i>Usnea oncodes</i> Stirton <sup>N</sup>	+	+
<i>Usnea</i> ca. <i>punctulata</i> G.N. Stevens		+
<i>Usnea pycnoclada</i> Vainio <sup>N</sup>		+
<i>Usnea rubicunda</i> (Stirton) var. <i>spilota</i> (Stirton) G.N. Stevens	+	+
<i>Usnea scabrida</i> subsp. <i>tayloriana</i> G.N. Stevens	+	
<i>Usnea subciliata</i> (Motyka) Swinscow & Krog	+	+
<i>Usnea xanthopoga</i> Nyl. <sup>N</sup>		+
<b>Total Species: 110</b> ( <sup>N</sup> 17)	<b>93</b>	<b>67</b>

<sup>N</sup> = Newly Recorded for Victoria  
50 species common to both forest types





## A note on *Lepidium strictum* (S. Watson) Rattan (Brassicaceae) in Victoria, Australia.

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### Abstract

*Lepidium strictum* (S. Watson) Rattan is shown to be the correct name for the species to which the name *L. pubescens* Desv. has been misapplied by Australian authors, following Thellung (1906).

### Introduction

In his paper "The South American species of *Lepidium*" (1945), Hitchcock showed that *L. strictum* (S. Watson) Rattan differs diagnostically from *L. pubescens* Desv. in having relatively large nectary glands c. 0.5 mm long and prominently reticulate-veined siliculae 2.5–3 mm long, and thus Thellung (1906) erred in reducing the former species to synonymy with *L. pubescens*.

Australian records of *L. pubescens* are referable to *L. strictum*. All relevant collections in MEL match Hitchcock's description and figure of the latter species (Hitchcock 1945), as do the descriptions and figures of *L. pubescens* in Hewson (1982) and Entwisle (1996).

### Taxonomy

*Lepidium strictum* (S. Watson) Rattan, *Anal. Key West Coast bot.* **25** 2<sup>nd</sup> edn (1888). Type: near Placerville [California, United States], Rattan (holotype GH *n.v.*, *fide* Hitchcock, *Madroño* **3**: 272 (1936)). *Lepidium oxycarpum* Torr. & Gray var. (?) *strictum* S. Watson, *Bot. California* **1**: 46 (1876).

*Lepidium pubescens* auct. non Desv., *J. Bot.* (Desvaux) **3**: 165, 180 (1814): Thellung, *Mitt. Bot. Mus. Univ. Zürich* **28**: 247 (1906); Hitchcock, *Madroño* **3**: 272 (1936); Willis, *Hand. Pl. Victoria* **2**: 175 (1973); Hewson, *Brunonia* **4**: 276 (1982); Entwisle, *Fl. Victoria* **3**: 420 (1996).

*Lepidium reticulatum* Howell, *Fl. N.W. Amer.* **i**: 64 (1897), non Thellung, *Mitt. Bot. Mus. Univ. Zürich* **28**: 253 (1906) = *Lepidium oblongum* Small.

Thellung (1906) lists a number of other misapplied or synonymous names but only one of these is relevant in an Australian context; the illustration cited in Willis (1973) for *L. pubescens*: Bettfreund, *Flor. Argent.* **2**: t. 78 (1900), is referred by Thellung to *L. bonariense* L.

### Discussion

The only collection of *L. pubescens* seen by Thellung was Desvaux's type specimen from Peru. Regarding *L. pubescens*, Hitchcock (1945) states "It seems remarkable that the identity of this species has remained uncertain so long. The large, pubescent-margined silicles and sharply toothed leaves are to be matched in no other American species." He adds: "The material which Thellung and I called *L. pubescens* (= *L. strictum*) differs among other ways in having very prominently reticulate and much smaller fruits, longer glands, persistent sepals and different leaves."

In Australia, *L. strictum* is a rare weed of urban areas, confined to Victoria (Entwisle 1996). Although the type is from California, Hitchcock (1945) states "The species

appears to be a rather recent introduction to North America as it is found chiefly near habitations." Rollins (1993) describes it as a sporadic species, mostly in towns and cities, occurring in Utah, California and Oregon. It is thus probable that *L. strictum* is native only to Chile, where it occurs between latitudes 27° and 34°S, mainly around Valparaíso and Santiago, with one northern collection from the coastal town of Caldera in Atacama province (Hitchcock 1945). It is interesting to speculate as to whether the species was introduced directly into Australia from Chile or secondarily via California. The transitory appearance at Tenterfield, N.S.W. of *L. oblongum* Small (California to Arkansas and south to Mexico and Guatemala) appears to support the latter possibility (see Hewson, 1982). The three other American species recorded for Australia shed no light on the problem as *L. bonariense* L. (SE South America), *L. densiflorum* Schrad. (North America) and *L. virginicum* L. (North and South America) are widespread and successful weeds, now established outside their original ranges in the Americas and adventive in Europe, Australia and New Zealand (Garnock-Jones 1988; Hernández Bermejo & Clemente 1993; Hewson 1982; Hitchcock 1936; Rollins 1993; Ryves 1977).

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## The Stomata of Bluegums (*Eucalyptus* spp.)

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### Abstract

Measurements of the sizes of the stomata of juvenile and adult leaves of Tasmanian blue-gum (*Eucalyptus globulus* Labill.) made over a long period and in diverse countries are collated. It is shown that in *E. globulus*, the sizes are independent of locality and whether the trees are natural or cultivated, that is almost certainly they are genetically determined. The stomata of adult leaves of different species of blue gums are larger, sometimes as much as twice as large, as those of the juvenile leaves. The upper surface of the juvenile leaves of three of the blue gum species bears few or no stomata and the internal structure of the (bifacial) leaf reflects this. The (unifacial) adult leaves always have stomata on both surfaces. The large adult/juvenile stomatal size ratio appears to be unique to bluegums since it does not occur in a range of other species investigated.

### Introduction

Although Vesque (1882) is usually credited with drawing attention to the usefulness of studies of leaf anatomy to systematics Mueller (1883) was already aware of and using features of leaf anatomy in his research. He wrote: "By the aid of the microscope we may yet hope to be able to obtain characteristics of diagnostic value from the anatomy of leaves sufficiently positive to recognise ordinal and even perhaps generic groups..." "I was enabled, for instance, to demonstrate the existence of Epacridae in New Guinea from the microscopic comparison of the leaf epidermis of a species, brought from thence without flowers or fruits, with the very peculiar cuticle of many Epacridae easily recognized microscopically." Mueller was the first to investigate the microscopic features of the leaf epidermis of eucalypts. In his *Eucalyptographia* (1879–1884) he illustrated the stomata of 39 species. He not only discussed differences in sizes of the stomata but also the differences between species in stomatal frequency (number per unit area of leaf surface). His younger contemporary, J.H. Maiden (1909–1928) referred (Vol. 1, p. 9) to Mueller's tentative classification based on the differences in distribution of stomata on the two leaf surfaces, but dismissed it, without citing supporting evidence, as "not reliable." Beyond this Maiden makes no further reference at all to stomata. Nevertheless, he does remark (*ibid*) "The anatomical characters of the leaves of *Eucalyptus* offer, however, much room for research."

In carrying out the statistically elaborate work for his 1973 doctoral thesis on Geographical variation in *Eucalyptus globulus* Labill. Kirkpatrick collected materials of bluegums, as the group of species to which *E. globulus* belongs is known, throughout south-eastern Australia.

His two papers on the topic (Kirkpatrick 1974, 1975) divide the group into four subspecies of which *E. globulus* proper is almost entirely Tasmanian with some outliers in southern Victoria, and *E. maidenii* F.Muell. is almost entirely restricted to the seaward slopes of south-western New South Wales. I differ from him in what follows in treating the entities he regards as subspecies as species in their own right (cf. also Chippendale 1988). The literature cited by Kirkpatrick is almost exhaustive of that on the bluegums: but there still remain some aspects of the bluegums, including some older literature, neither mentioned nor discussed. One of these aspects goes back to the work of Mueller.

It concerns the stomata of *E. globulus*. To Mueller, that name covered all the species (or subspecies) of bluegum now recognised (except *E. maidenii*) so it is difficult to be sure that his work on stomata really concerned only the Tasmanian species. Nevertheless,

the illustration to his description of the species (Mueller 1879–84) is, as far as one can tell, true to the concept of *E. globulus* put forward by Labillardière in 1800 and 1806. Nevertheless, whereas *E. globulus* (in Labillardière's sense) has inflorescences each consisting of a single flower, an unnumbered picture of a three-flowered inflorescence is included in the Plate (Decade 6) without any comment in the legend. I think that Mueller would have been cautious enough to realise the possibility of his specimen not being *E. globulus sensu stricto*.

In constructing Table 1 I was unable to trace two references to *E. globulus* in early pharmacological journals, referred to by Maiden (1909–1920, Vol 1, p 7) which might contain measurements of stomata. Lacking funds to collect for my work, materials from the "wild," I requested, but was unable to obtain, access to Kirkpatrick's specimens but they had been returned to the collector. However there are plantings of most species of

**Table 1.** Stomatal size\* and frequency in *E. globulus*

Author		Juvenile			Adult	
		Size $\mu\text{m}$	Frequency $\text{mm}^2$		Size $\mu\text{m}$	Frequency $\text{mm}^2$
Mueller	upper		70	upper	60	
	lower	132		lower	51	87
Briosi	upper			upper		
	lower	40–60	162	lower	80–100	59
Johnson	upper			upper	53	86
	lower	29	83.8	lower	54	86
Carr and Carr (1)	upper			upper		
	lower	27	142	lower	53	
Carr and Carr (2)	upper			upper	(na)	
	lower	26.5	191	lower	(na)	
Carr and Carr (3)	upper			upper		
	lower	27.6	127	lower	53.3	
Carr and Carr (4)	upper			upper		
	lower	35.4		lower	58.3	
Maiden & Mansfield (1968)	upper			upper		
	lower	31		lower		
Ridge, R.W. (1980)	upper			upper	56	129
	lower			lower	57	63.6

\*The size measurements in all Tables are of stomatal length (micrometres) (means of 30 determinations).



bluegums in the Canberra area (Pryor 1951) and I turned to these for materials. We did have some specimens of *E. globulus* obtained from A.K. Cameron.

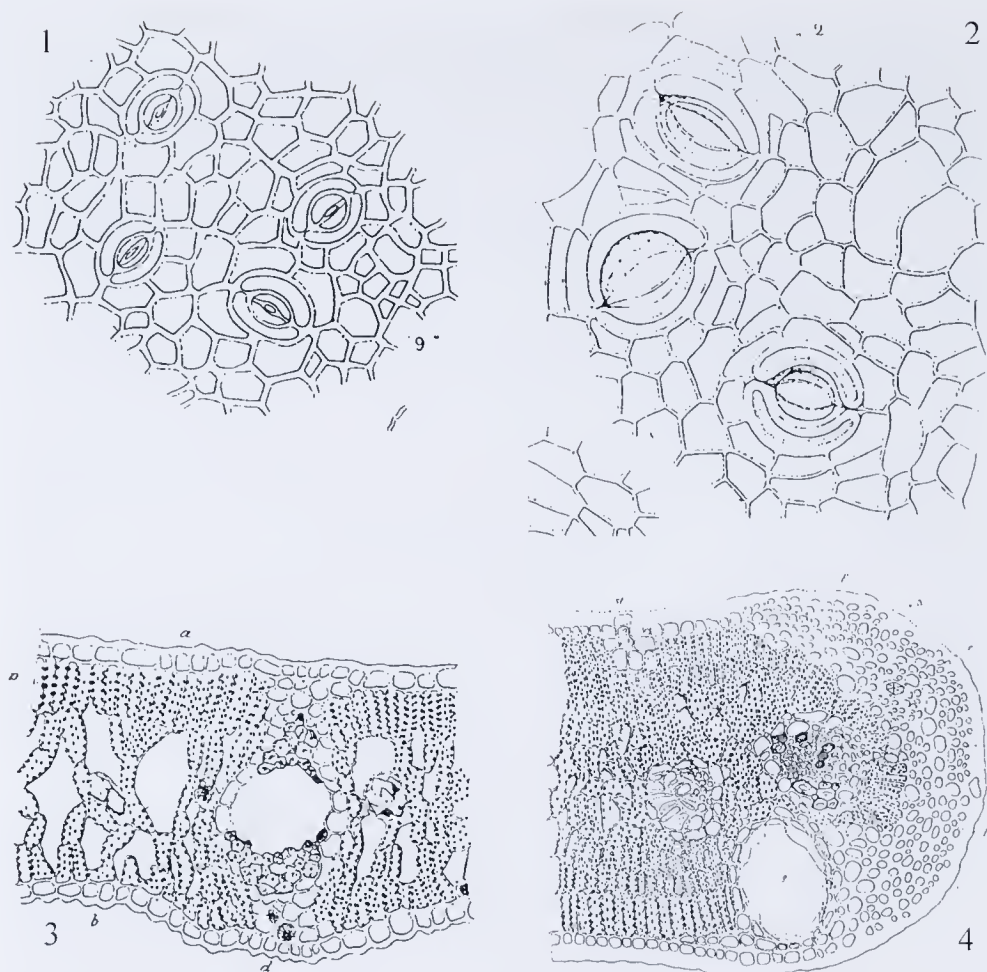
Subsequent to Mueller's research on *E. globulus* a monograph appeared in Italy on the leaf of *Eucalyptus globulus* which included a number of measurements and drawings of stomata (Briosi 1892). Since then a number of other measurements have been made, published or not, on the stomata of bluegums including *E. globulus*, which (in its narrow sense) (*contra* Kirkpatrick) is not widely grown on the mainland of Australia but is or was widely grown abroad. However, in the last few years, extensive plantings of *E. globulus* have been made for timber and woodchips in southern and south-western Western Australia and in western Victoria.

Table 1 shows three remarkable things. One is the extraordinary consistency of the measurements on a single species, especially of the stomatal lengths over more than one hundred years and in places separated by the diameter of the earth, and irrespective of seed provenance. This attests to inherent that in *E. globulus* stomatal length is under strict genetical control. The only aberrant data are those of Briosi, which are twice those of all the other observers. The second remarkable thing is that in all but one case (Mueller) there were no stomata recorded on the upper side of the juvenile leaves. The third, is that in all cases the stomata on the lower side of the juvenile leaves were about or just under one half the length of those of the adult. Omitting Briosi's measurement the mean of the juvenile stomatal lengths is 29.4  $\mu\text{m}$  with a standard deviation (SD) of 3.06; that of the adult stomata 54.6 SD 1.95. Thus the ratio of the two means is 1.86. This is also the case in the measurements of Briosi, which leads me to believe that his measurements suffer from a systematic error, perhaps in the calibration of his instruments. If his magnifications (given as  $\times 300$ ) were actually  $\times 450$  (as were Mueller's) the adult stomata illustrated in Briosi's Plate III Fig 2 would be 55  $\mu\text{m}$ , not 80 to 100 as stated.

The Carr and Carr measurements were from specimens collected by A.K. Cameron and A.M. Gray in Tasmania. They had no stomata (Carr and Carr 2 & 4) or very few (1 and 3) (less than 1  $\text{mm}^2$ ) on the upper surface of the juvenile leaves; another specimen from Flinders Island, Bass Strait had none. The juvenile leaves of Mrs Carr's undated and unnumbered specimen from Squeaky Bay, Victoria, about as close a locality as one can get to Tasmania on the mainland of Australia, also lacked upper surface stomata. On the other hand, a specimen collected (as '*E. globulus*') by Cameron in Toorak, Melbourne, Victoria, had stomata on both surfaces of the juvenile leaves, with a frequency of 31 (upper) and 42 (lower)  $\text{mm}^2$ . Johnston (1926) recorded "a few" stomata along the midrib on the upper surface of the juvenile leaves, evidently too few to record their frequency (*c.f.* Carr and Carr 1 & 3). The material she used was a plant grown in a greenhouse at Manchester. The material of Meidner and Mansfield (1968) was also a seedling grown in an English greenhouse. Mueller, whose concept of the species *E. globulus* was extremely wide (as already mentioned), found stomata on the upper surface of the juvenile leaves, reported by none of the other authors (but *c.f.* the Toorak specimen of Cameron). One cannot therefore be certain that Mueller's data refer to *E. globulus* in the narrower, modern sense. The size reported in Table 1 is from a drawing, together with its magnification, of a single stoma.

The stomata of the juvenile leaves of *E. globulus* (in the narrow sense) are therefore essentially restricted to the lower surface. This has implications for the internal structure of the leaf, which differs in this from the adult leaf which, having stomata on both sides, has also a layer or layers of palisade parenchyma below each leaf surface (Figs. 1–4). This, of course was already known to Briosi (1892: 106–107) but has escaped the notice of subsequent writers (e.g. Maiden. 1909–1920 (Vol 1: 7; 6: 287); Penfold & Willis 1961), who cite his publication. Nevertheless Maiden (1: 7) described Briosi's monograph as "a masterly paper." Knowledge thus won early has subsequently been forgotten.

We must ask if these findings extend to the other bluegum species.



Figures 1–4. All illustrations of leaves of *Eucalyptus globulus* from the publication by Briosi, (1892). 1 Stomata of a juvenile leaf. 2 Stomata of an adult leaf. 3 Section of a juvenile leaf with stomata only on the lower surface. 4 Section of a mature adult leaf.

### Materials and Methods

Ausing cuticle preparations were obtained by chemical maceration in a heated mixture of glacial acetic acid and 100 vol. hydrogen peroxide (1:5), stained and mounted in glycerin-jelly. The measurements were made using a calibrated eyepiece micrometer and frequency measurements with an eyepiece graticule.

### Observations

The observations (Tables 2–6) show that the juvenile leaves of *E. st. johnii* (R.T.Baker) (a species subsumed by Kirkpatrick into his *E. pseudoglobulus*) and *E. bicostata* Maiden also lack stomata on the upper surface and therefore have an internal structure like that of the juvenile leaves of *E. globulus*. But the juvenile leaves of the other species always have stomata on both surfaces, like the adult leaves of all. Thus, it matters not that such juvenile leaves are (as Briosi called them) “horizontal,” the two surfaces illuminated unequally, and therefore (according to him) theoretically predisposed to be bifacial and have stomata confined to the lower surface whereas the vertically hanging adult leaves, as expected, are unifacial.

These facts stand, of course, in contrast to one of Kirkpatrick’s statements (1974). “No discontinuities are evident in any of the 30 adult and juvenile characters studied over the total range of blue gum.” The results reported below (Table 2) are quite preliminary and they must be taken as tentative and requiring confirmation and expansion. To go further with the comparisons would require a considerable research undertaking.

**Table 2.** *E. bicostata*, size of stomata (µm).

	Juvenile	Adult
Anzac Parade	33.5	55.8
Yarralumla	30.4	56.8

Ratio of adult/juvenile 1.78.

Of bluegum trees growing in Canberra *E. bicostata* is by far the commonest. In addition to cultivated trees of *E.st.johnii* I was also fortunate enough to have access to type material of that species collected by the eponymous E. St John from the Lerderderg Gorge in Victoria.

**Table 3.** *E. st johnii*. (= *E. pseudoglobulus* of Kirkpatrick) (lower surfaces)

	Juvenile	Adult
Lerderderg Gorge (E. St.John)	size 32.6µm freq. 266	57.4 µm 224.5
ANU campus site	36.58 freq. 187	46.17 —
near Mosque	size 39.68	54.7

The ratio of the (size) means) adult/juvenile is 1.47

As juvenile leaves of *E. maidenii* were not accessible I was forced to examine a number of herbarium specimens. One of these, *Beaglehole* 33943, had originally been identified as *E.st.johnii*, then was re-identified by Brooker as *E. pseudoglobulus* and subsequently used under that name as the voucher for a drawing of its three-flowered inflorescence in the Flora of Australia (Chippendale 1988). Its identification seems to me to be wrong and I believe that it is an unusual specimen of *E. maidenii*. For instance, the juvenile leaves have stomata on both surfaces like *E. maidenii* but unlike *E. pseudoglobulus*. The following are measurements of stomatal length in micrometres from the lower surfaces of the leaves.

**Table 4.** *E. maidenii*, size of stomata (lower sufaces)

	Juvenile	Adult
de Beuzeville 588 Eden NSW	29.05	58.7
de Beuzeville 587 Eden NSW	32.7	60.45
Beaglehole 33682 Genoa, Victoria	32.83	51.4
Beaglehole 33943 Tara Range, Vic.	28.163	62.46

The overall ratio of means of adult/juvenile sizes is 1.9. In some specimens (e.g. *Beaglehole* 33943) it is greater than 2.

Thus the ratios of the means of adult to juvenile sizes are as follows: *maidenii* 1.9, *globulus* 1.86, *bicostata* 1.67, *st.johnii* (= *pseudoglobulus*) 1.47. Clearly the adult stomata of *E. maidenii* are by far the largest of any of the blue gums.

We are left with a puzzle: what are the so-called *E. globulus* specimens in and around Melbourne which superficially look like that species but have juvenile leaves with large numbers of stomata on the upper surface? They cannot be *E. pseudoglobulus* which lacks such stomata. The late J.H Willis also had difficulty with such specimens. "*E(ucalyptus) st.johnii* sometimes overlaps with occurrences of typical *E. globulus* (e.g. on Wilson's Promontory, Phillip Island and the Otways), where puzzling intermediate populations occur" (1973, 2: 419). Such so-called "intermediates" would include the specimen examined by Mueller (Table 1) and the Cameron specimen from Toorak. Evidently some trees identical with the real, Tasmanian, *E. globulus* exist in southern Victoria (like the one from Squeaky Bay, Wilsons Promontory), as one might expect since Tasmania has been isolated from the mainland only since the end of the last ice-age. But it is not possible immediately to classify the other specimens from the vicinity of Melbourne.

During one of my visits to California I collected a specimen of a locally grown variety (*E.globulus* var.*compacta* Maiden) near Santa Barbara. It is listed in Chippendale (1988) as a hybrid.

**Table 5.** *E. globulus* var. *compacta*. (size of stomata  $\mu\text{m}$ )

Juvenile	Adult
upper 39.76	upper 38.29
lower 33.18	lower 41.25
For comparison: Cameron Toorak (as " <i>E. globulus</i> ")	
upper 26.18	upper 39.0
lower 33.32	lower 40
Ratios adult/juvenile (lower surfaces) <i>compacta</i> 1.2; Cameron Toorak 1.2)	

The var. *compacta* ratio (Table 5) might suggest some relationship with *E. pseudoglobulus*, some specimens of which (e.g. those on the ANU campus) have a ratio of 1.2, rather than with *E. globulus*. However the fact that the juvenile leaves have stomata on both surfaces, unlike *E. pseudoglobulus*, does not support that possibility. The data added for the Toorak specimen of Cameron labelled '*E. globulus*' present a striking similarity except for the lengths of the stomata on the upper surfaces of the juveniles. Further work is suggested on the blue gums of Santa Barbara and those around Melbourne. Unfortunately the Santa Barbara tree appeared to be sterile, at least I saw on it no fruits or flowers.

## Discussion

The ability to illuminate relationships within the bluegums by examining the leaf anatomy suggests that it, rather than characters such as the number of buds in the inflorescence, might be the better determinant. For instance, it is quite clear that stomatal sizes and distribution easily distinguish between *E. pseudoglobulus* and *E. maidenii* (as in the case of *Beaglehole* 33943).

A corollary of the measurements reported above, which include some measurements on juvenile foliage not from seedlings but from what are called "reversion shoots" on adult trees, is that the characters of the juvenile leaves are repeated when, in the production of these reversion shoots, the adult tree produces another set of juvenile leaves. These shoots usually begin with a few leaves, identical in shape and glaucousness to those of the sapling



and to these characters we may now add those of the stomata. The sizes and locations of the stomata are identical with those of the seedling and sapling. Then as the reversion shoot develops, leaves identical with the adult leaves in all characters, including those of the stomata, are produced. This is quite a remarkable performance since it implies that a whole suite of juvenile characters, presumably all genetically determined and including cell size (since stomatal size appears so), is switched on and then in the course of the early development of the succeeding leaf primordia they are switched off and all replaced simultaneously by a different suite of adult characters, also genetically determined. Of course this performance merely repeats what occurs during normal "phase change" (juvenile to adult) during the normal growth of the tree, but in its recurrence and spontaneity it is very striking. During the slow development of the bark-enclosed residual meristem (which gives rise to the reversion shoot), in turn derived from an accessory bud on the growing shoot, there must be some reprogramming of the genetic material of the cells of the meristem to an embryonic state like that of the seedling; this state then changes rapidly during reversion shoot growth back to the adult condition (see Carr 1984).

In a previous publication (Carr & Carr 1991), we stated (without citing data) that "the size of the guard cells (of juvenile leaves of eucalypts) is smaller than those of the adult leaves. This I re-investigated in 7 species growing in my own garden or nearby in Canberra. The results are given below in Table 6.

**Table 6.** Comparisons of measurements of sizes of juvenile and adult stomata in some species of *Eucalyptus*.

Species ratio	adult/juvenile	significance
<i>quadrangulata</i> Deane & Maiden	1.220	p< 0.05
<i>cinerea</i> F Muell. ex Benth.	1.019	ns
<i>bridgesiana</i> R.T.Baker	1.136	ns
<i>melliodora</i> Cunn. ex Schauer.	1.205	ns
<i>leucoxydon</i> F.Muell.	1.1072	ns
<i>sideroxydon</i> Cunn. ex Woolls	1.1065	ns
<i>perriniana</i> F.Muell. ex Rodway	1.1535	p< 0.001

It will be clear that the results are equivocal. In all cases the measurements showed that the adult stomata were a little larger but the data when subjected to statistical test the differences were significant only in two cases (ns = not significant). The great differences in the bluegums appear therefore to be unique to that group of species. The number of stomata measured in each case was 30 for each surface and the tests were by t test. Perhaps if a larger sample of the stomata were measured in each case the differences observed might achieve significance. However, the differences are too small to warrant a fuller investigation.

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**Identified types in the Wilhelm Hillebrand collections in the herbarium of the Royal Botanic Gardens, Melbourne.**

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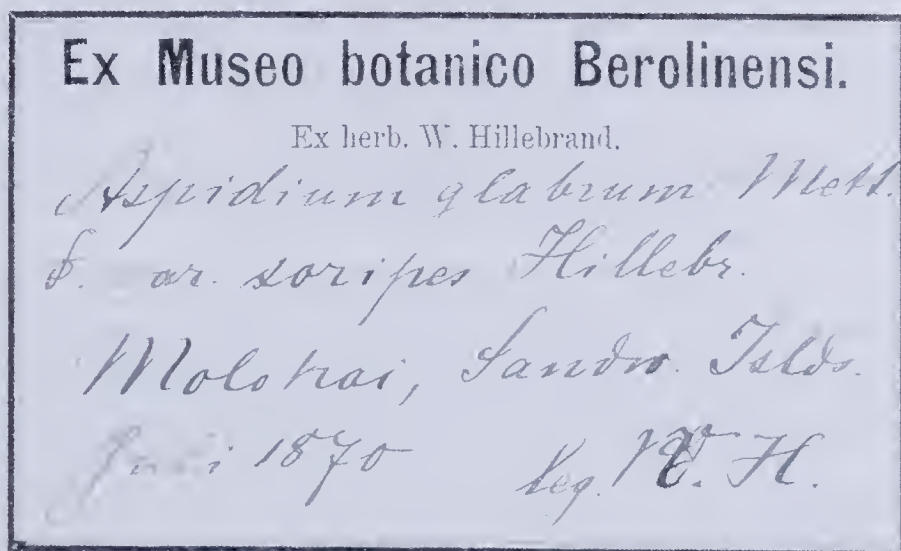
*Abstract*

A list of clearly identified and probable types from the Hawaiian collections of Wilhelm Hillebrand is presented. Of the well over 200 taxa published by Hillebrand, there are 102 verified types, and 4 possible types deposited at MEL. A short discussion of how these collections came to be deposited at MEL is provided.

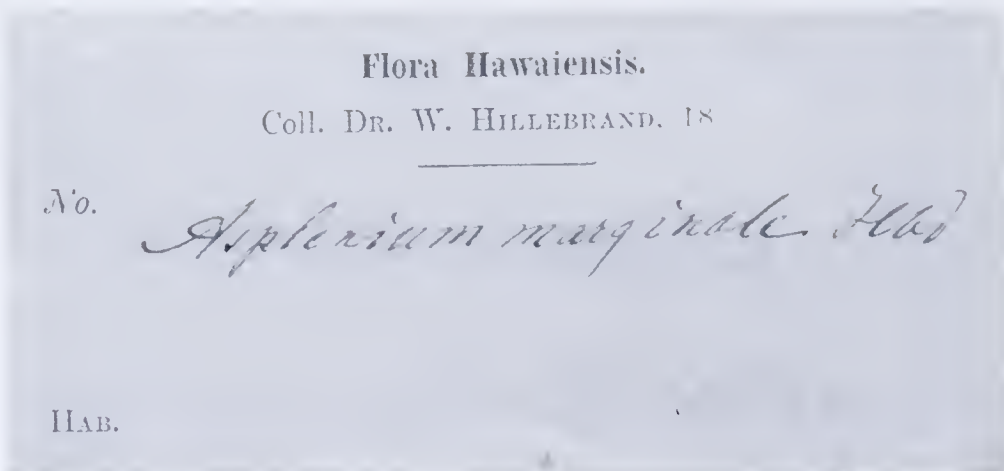
**Introduction**

Wilhelm Hillebrand, Prussian physician, lived for 20 years in Hawai'i and amassed a personal herbarium of 12,000–15,000 sheets (Lammers 1994). This herbarium was the basis of his *Flora of the Hawaiian Islands* (1888), published by his son two years after his death. When Hillebrand died his herbarium was bequeathed to the Berlin-Dahlem Museum, and his collections were among those destroyed during World War II. Duplicates of his collections are fairly widely distributed (Stafleu & Cowan 1979), and it is reported in *Taxonomic Literature II* that a set of duplicates is present at MEL. Nonetheless, no information about these collections has yet been published; consequently, the collections at MEL are often not included in discussions of Hillebrand's duplicates (cf. Sayre 1975).

Ferdinand Mueller, first Government Botanist of Victoria, managed to acquire an impressively large set of duplicate collections from around the world. Unfortunately it



**Figure 1.** An example of the kind of label found on all of Hillebrand's types lodged at MEL.



**Figure 2.** An example of a second kind of label found on Hillebrand's types of ferns.

cannot be known for certain when and how most of these specimens came to be at MEL as F. Mueller's correspondence was destroyed during a move of the MEL herbarium in 1934–35 (Pescott 1982). In the case of the Hillebrand collections there is contradictory information. For instance, all collections at MEL have labels stating 'Ex Museo botanico Berolinensi.' (Fig. 1), leading one to believe the plants were distributed from B, and, given the consistency in the labels, that they came in one shipment. However, the pteridophytes have not only this kind of label, but also a second (Fig. 2). It is possible that the ferns came in a separate shipment.

Mueller lists Hillebrand in his Annual Report of the Government Botanist to Parliament, 1864–65, (MEL library archives) as having donated dried plant specimens; but Hillebrand's collections were bequeathed to B after his death, and, in 1865 he was still living in Hawai'i. These collections therefore are undoubtedly not part of the *Reliquae Hillebrandianae*. It is reported (Corn 1983) that Hillebrand and Mueller became friends when Hillebrand went plant collecting with Mueller during a visit to Australia, and Corn states (1983) that the two are known to have exchanged plant material.

Though the two men collected together, in only one instance have I found that a Hillebrand collection from Australia is cited as a syntype for a species described by Mueller (i.e., *Erysimum blennodes*); however, no syntype is deposited at MEL. Furthermore, though other species are named by Mueller in honour of Hillebrand (e.g., *Eriostemon hillebrandii*, *Veronica hillebrandii*), no duplicates of any collections made by Hillebrand in Australia have been found at MEL. How large the set of his collections from Australia, and if he kept them in his personal herbarium, is not known. It is likely they were destroyed at B.

Corn (1983) first brought attention to the duplicate set of Hillebrand's collections deposited at the Royal Botanic Gardens, Melbourne. She noted that she photographed 569 sheets of flowering plants and ferns, and distributed copies of these photos (Corn, 1983, unpublished ms.). Apparently no collections of lower plants or fungi are represented. Most of the foreign material that Mueller acquired for MEL remains unmounted. And though Corn did search through the Polynesian set, she did miss some specimens. It is therefore likely that there is somewhat more than the 569 sheets reported by Corn deposited in MEL.

As Hillebrand's own herbarium bequeathed to Berlin was destroyed, and duplicates of his collections are widely distributed, typification of his names remains a problem (Lammers 1994). It is unlikely that any herbarium has a complete set of his duplicates. As was typical for 19<sup>th</sup> century collectors, types were not clearly designated by



Hillebrand. It is in the interest of informing researchers who may have to designate lecto- or neotypes, that a list of clearly identified or probable duplicates of the syntypes present in MEL is herein presented. If lectotypification or neotypification has already been done, that is noted. It should not be assumed that this list is complete, as the unmounted material in the foreign herbarium at MEL still surpasses 250,000 sheets.

Following the basionyms, synonyms are provided and are taken from Wagner *et al.* (1990), unless otherwise stated. Following in single quotes is any information on the label (other than the plant name) presented verbatim. When a type has been annotated by another researcher that it also noted. Ferns are presented first, then flowering plants in alphabetical order by family. As Hillebrand did not assign collection numbers, the MEL herbarium number of each sheet is given.

Of the 560-some collections by Hillebrand reported at MEL, verified types are listed below. Though an insignificant number of collections in comparison to the estimated size of Hillebrand's herbarium, the number of duplicate types is substantial.

### List of verified types

#### PTERIDACEAE

- Aspidium glaberrimum* Mett. var. *soripes* W.F. Hillebr., Fl. Haw. Is., 577. 'Molokai, Sandw. Islds. Juli 1870. Leg. W.H.' (MEL 587939).  
*Asplenium insititum* Brack. var. *grandipinna* W.F. Hillebr., Fl. Haw. Is., 599. 'Kaala; Oahu. 3000 ft. No. 43<sup>c</sup>. coll. D. Baldwin.' (MEL 1520643).  
*Asplenium mannii* W.F. Hillebr. var. *dareoides* W.F. Hillebr., Fl. Haw. Is., 595. 'Makaleha, Sandw. Is. coll. W.H.' (MEL 587940).  
*Asplenium marginale* W.F. Hillebr., Fl. Haw. Is., 613. 'Molokai.' (MEL 1520441).  
*Asplenium pseudofalcatum* W.F. Hillebr., Fl. Haw. Is., 599. 'Oahu, Nuuanu, Molokai (Halawa).' (MEL 587944) and 'Oahu, Sandw. Is.' (MEL 587945).  
*Asplenium sphenotomum* W.F. Hillebr., Fl. Haw. Is., 599. 'Kauai, coll. Knudsen.' (MEL 587947).  
*Polypodium tamariscinum* Kaulf. var. *montanum* W.F. Hillebr., Fl. Haw. Is., 556. 'Kauai, Sandw. Islds.' (MEL 1520613).  
*Pteris irregularis* Kaulf. var. *linearis* W.F. Hillebr. Fl. Haw. Is., 628. 'as *Pteris irregularis* Kaulf. b. Sandw. Islds.' (MEL 1520621).

#### APOCYNACEAE

- Vallesia macrocarpa* W.F. Hillebr., Fl. Haw. Is., 297 = *Pteralyxia macrocarpa* (W.F. Hillebr.) K. Schum. 'Oahu, leg. Hbd.' (MEL 587762).

#### ARALIACEAE

- Triplasandra meiandra* W.F. Hillebr., Fl. Haw. Is., 152 = *Tetraplasanda oahnensis* (A. Gray) Harms 'Wailupe.' (MEL 587937).

#### ASTERACEAE

- Argyroxiphium virescens* W. F. Hillebr., Fl. Haw. Is., 219. 'OH. Maui. Sandw. Is. leg. Lydgate.' (MEL 1520480).  
*Campylotheca macrocarpa* W.F. Hillebr. b var. *ovatifolia* W.F. Hillebr., Fl. Haw. Is., 214 = *Bidens macrocarpa* (A. Gray) Sherff. As 'Campylotheca macrocarpa var. b Oahu. leg. Hnd.' (MEL 1520559).  
*Campylotheca molokaiensis* W.F. Hillebr., Fl. Haw. Is., 212 = *Bidens molokaiensis* (W.F. Hillber.) Sherff. 'Molokai. Sandwich Inseln. leg. Hbd.' (MEL 1520478).  
*Dubautia laxa* Hook & Arn. var. *hirsuta* W.F. Hillebr., Fl. Haw. Is., 223 = *Dubautia laxa* subsp. *hirsuta* (W.F. Hillebr.) G. Carr 'W. Maui. Sandw. Inns. leg. Hbd.' (MEL 1520387).  
*Hesperomannia arborescens* W.F. Hillebr., Fl. Haw. Is., 232. 'W. Maui. Sandw. Ins. Leg. Bishop.' (MEL 1520560).

- Lipochaeta hastata* W.F. Hillebr., Fl. Haw. Is., 208 = *Lipochaeta heterophylla* A. Gray 'Lanai, Sandw. Ins. leg. Hbd.' (MEL 78098).
- Raillardia molokaiensis* W.F. Hillebr., Fl. Haw. Is., 226. 'Molokai, Sandwich Islands. leg. Hbd.' (MEL 78108). According to Carr (1990, Man. Fl. Pl. Hawaii, p. 292) this is a hybrid between *Dubautia linearis* subsp. *opposita* and *D. scabra* subsp. *leiophylla*.
- Reuya maniensis* W.F.Hillebr., Fl. Haw. Is., 194. 'Maui, Sandw. Ins. leg. Hbd.' (MEL 78112).
- Tetramolopium filiforme* Sherff, var. *filiforme*, Bot. Gaz. 95: 498 (1934). ISOTYPE, *fide* T. Lowrey, 1986. As '*Tetramolopium teuerrinum* N. Oahu. leg. Hbd.' (MEL 78119).
- Tetramolopium lepidotum* (Lessing) Sherff var. *luxurians* W.F. Hillebr., Fl. Haw Is., 199. LECTOTYPE, design. by T. Lowrey, 1986 = *Tetramolopium lepidotum* subsp. *lepidotum*. As '*Tetramolopium chauiisouis b luxurians*. Oahu. leg. Hbd.' (MEL 78115).
- Wilkesia grayaya* W.F. Hillebr., Fl. Haw. Is., 220 = *Argyroxiphium grayanum* (W.F. Hillebr.) Degener. 'W. Maui, Sandw. Inl., leg. Hbd.' (MEL 78120).

## BRASSICACEAE

- Lepidium arbuscula* W.F. Hillebr., Fl. Haw. Is., 10. 'Oahu, Waianae. leg. Hillebrand.' (MEL 1520481).

## CAMPANULACEAE

- Clermontia coerulea* W.F. Hillebr., Fl. Haw. Is., p. 243. ISOLECTOTYPE design. Rock, 1919, *fide* T. Lammers, 1991. = *Clermontia clermontioides* (Gaudich.) A. Heller subsp. *clermontioides* 'Hawaii. leg. Hillebrand.' (MEL 587783).
- Clermontia macrocarpa* Gaudich. var. *rosea* W.F. Willebr., Fl. Haw. Is., p. 240. LECTOTYPE, design. T. Lammers 1991: 39 = *Clermontia kakeana* Meyen. 'Oahu. leg. Hillebrand.' (MEL 587786).
- Clermontia multiflora* W.F. Hillebr., Fl. Haw. Is., 242. 'Oahu. leg. Hillebrand.' (MEL 587767). Ver. T. Lammers, III/89. Though Lammers annotated this as an ISOLECTOTYPE, it was not cited in his monograph of *Clermontia* (1991).
- Clermontia multiflora* W.F. Hillebr. var. *micrantha* W.F. Hillebr., Fl. Haw. Is., 242. ISOLECTOTYPE, design. by T. Lammers 1991: 59. 'Maui. leg. Hillebrand.' (MEL 587837).
- Clermontia pallida* W.F. Hillebr., Fl. Haw. Is., 241. ISOLECTOTYPE, design. by T. Lammers, 1991: 50. 'Molokai, Sandw. Ins. leg. Hillebrand.' (MEL 587839).
- Cyanea comata* W.F. Hillebr., Fl. Haw. Is., 256. SYNTYPE, ann. T. Lammers, III/89 'Haleakala, W. Maui. Sandw. Ins. leg. Hillebrand.' (MEL 587857).
- Cyanea gibsonii* W.F. Hillebr., Fl. Haw. Is., 263. LECTOTYPE design. T. Lammers, 1988: 503 = *C. macrostegia* W.F. Hillebr. subsp. *gibsonii* (W.F. Hillebr.) Lammers. 'Lanai, Sandw. Ins. leg. Hillebrand.' (MEL 587859)
- Cyanea holophylla* W. F. Hillebr., Fl. Haw. Is., 257. ISOLECTOTYPE, design. by T. Lammers, 1994: 559. = *C. scabra* W. F. Hillebr. (MEL 587861).
- Cyanea macrostegia* W.F. Hillebr., Fl. Haw. Is. 263. ISOLECTOTYPE, design. by T. Lammers, 1994: 562. = *Cyanea macrostegia* W.F. Hillebr. subsp. *macrostegia*. 'West, Maui, Sandw. Ins. leg. Hillebrand.' (MEL 587856).
- Cyanea scabra* W.F. Hillebr., Fl. Haw. Is., 256. SYNTYPE, ver. T. Lammers, *in annot.* 1989. 'Kaanapali, W. Maui, Sandwich I. leg. Hillebrand.' (MEL 587930).
- Cyanea solanacea* W.F. Hillebr., Fl. Haw. Is., 259. SYNTYPE, ver. T. Lammers, *in annot.* 1989. 'Kalae auf Molokai, Sandw. Ins. leg. Hillebrand.' (MEL 587931).
- Cyanea solenocalyx* W.F. Hillebr., Fl. Haw. Is., 258. SYNTYPE, ver. T. Lammers, *in annot.* 1989. 'Molokai, Sandw. ins. leg. Hillebrand.' (MEL 587929).
- Cyanea superba* A.Gray var. *velutina* Rock, Monogr. Stud. Haw. Lobelioid. 157. 1919. ISOTYPE, ver. T. Lammers, *in annot.* 1989. = *Cyanea superba* A.Gray subsp. *superba*. As '*Cyanea superba* Gray var. b. Oahu. leg. Hillebrand.' (MEL 587769).

*Delissea lacinata* W.F. Hillebr., Fl. Haw. Is., 249. SYNTYPE, ver. T. Lammers, *in annot.* 1989. 'Oahu. leg. Hillebrand.' (MEL 587773).

*Lobelia hypoleuca* W.F. Hillebr., Fl. Haw. Is., 238. 'West Maui. Sandw. Ins. leg. Hillebrand.' (MEL 587836).

*Rollandia grandifolia* Hillebr. Fl. Haw. Is., 245. SYNTYPE, ver. T. Lammers, *in annot.* 1989 = *Rolandia crispa* Gaudich. 'Oahu. leg. Hillebrand.' (MEL 587834).

## CYPERACEAE

*Carex montis-eeka* W.F. Hillebr., Fl. Haw. Is., 486. 'Mount Eeka, Sandw. Ins. leg. Hillebrand.' (MEL 587892).

*Cyperus hillebrandii* Boeck., Flora 63: 436 (1880). ISOTYPE, ver. J. H. Kern, 1953 'Haleakala, leg. Hillebrand.' (MEL 587896).

*Cyperus polystachys* Rottb. var  $\beta$  *pallidus* W.F. Hillebr., Fl. Haw. Is., 463 = *Pycnus polystachyos* (Rottb.) P. Beauv. 'Sandwich insula. leg. Hillebrand.' (MEL 587900).

*Rhynchospora spicaeformis* W.F. Hillebr., Fl. Haw. Is., 477. = *Rhynchospora chineusis* Nees & Meyen subsp. *spiciformis* (W.F. Hillebr.) T. Koyama. 'W. Maui. Sandw. Ins.' (MEL 587912).

## EUPHORBIACEAE

*Antidesma pulvinatum* W.F. Hillebr., Fl. Haw. Is., 403. 'Hawaii. leg. Hillebrand.' (MEL 587938).

*Euphorbia hookeri* Steud.  $\beta$  var *integrifolia* W.F. Hillebr., Fl. Haw. Is., 397 = *Chamaesyce multiformis* (Hook. & Arn.) Croizat & Degener. 'Maui. Sandwich ins. leg. Hillebrand.' (MEL 1520552).

## GERANIACEAE

*Geranium trideus* W.F. Hillebr., Fl. Haw. Is., 55 = *G. cuneatum* Hook subsp. *trideus* (W.F. Hillebr.) Carlq. & Bissing. 'Haleakala. Sandw. Ins. leg. Hillebrand.' (MEL 1520566).

*Geranium humile* W.F. Hillebr., Fl. Haw. Is., 56. 'On the summit of Mt Eika. leg. Hbd.' (MEL 1520565).

## GESNERIACEAE

*Cyrtandra biserrata* W.F. Hillebr., Fl. Haw. Is., 329 'Molokai. Sandwich Inseln. Leg. Hbd.' (MEL 587948).

*Cyrtandra filipes* W.F. Hillebr., Fl. Haw. Is., 336. 'W. Maui. Sandwich Inseln. leg. Hbd.' (MEL 587918).

*Cyrtandra gracilis* W.F. Hillebr., Fl. Haw. Is., 333. 'Oahu. Leg. Hbd.' (MEL 587919).

*Cyrtandra grayana* W.F. Hillebr., Fl. Haw. Is., 330. 'Maui. Sandwich Inseln. Leg. Hbd.' (MEL 587920).

*Cyrtandra latebrosa* W.F. Hillebr. Fl. Haw. Is., 337 = *Cyrtandra hawaiiensis* C. B. Clarke. 'Oahu. leg. Hbd.' (MEL 587932).

*Cyrtandra lydgatei* W.F. Hillebr., Fl. Haw. Is., 335 'Maui. Sandwich Ins. leg. Hbd.' (MEL 587922).

*Cyrtandra macrocalyx* W.F. Hillebr., Fl. Haw. Is., 329. 'Molokai. Sandwich Inseln. leg. Hbd.' (MEL 587924).

*Cyrtandra paritiifolia* W. F. Hillebr., Fl. Haw. Is., 328 = *C. hashimotoi*  $\times$  *C. platyphylla*. 'Maui. Sandwich Inseln. leg. hbd.' (MEL 587926).

*Cyrtandra procera* W.F. Hillebr., Fl. Haw. Is., 329. 'Molokai. Sandw. Inseln. Leg. Hbd.' (MEL 587926).

## GOODENIACEAE

*Scaevola cylindrocarpa* W.F. Hillebr., Fl. Haw. Is., 268 = *Scaevola channissoniana* Gaudich. 'Lanai. Sandwich Inseln.' (MEL 587831).

*Scaevola procera* W.F. Hillebr., Fl. Haw. Is., 268. 'Molokai. Sandwich Inseln.' (MEL 587832).

## LAMIACEAE

*Haplostachys rosuarinifolia* W.F. Hillebr., Fl. Haw. Is., 347 = *Haplostachys linearifolia* (Drake) Sherff. 'Molokai, Sandwich Inseln.' (MEL 1520492).

*Phyllostegia aubigua* (A. Gray) W.F. Hillebr. var. *lougipes* W.F. Hillebr., Fl. Haw. Is., 350 = *Phyllostegia warshaueri* St. John. 'Maui, Sandwich Inseln. leg. Lydgate.' (MEL 587949).

*Phyllostegia lispida* W.F. Hillebr., Fl. Haw. Is., 353. 'Molokai, Sandwich Insel. leg. Hbd.' (MEL 587950).

*Stenogyne bifidia* W.F. Hillebr., Fl. Haw. Is., 358. 'Molokai, Sandwich Inseln.' (MEL 587951).

*Stenogyne viridis* W.F. Hillebr., Fl. Haw. Is., 361. 'Maui, Sandwich Inseln. leg. Hbd.' (MEL 587954).

## LOGANIACEAE

*Labordia grayana* W.F. Hillebr., Fl. Haw. Is., p. 290 = *Labordia hedyosinifolia* Baill. 'Maui, Sandwich Inseln. leg. Hbd.' (MEL 587790)

*Labordia lophocarpa* W. F. Hillebr., Fl. Haw. Is., p. 289 = *Labordia waiolau* Wawra 'Molokai, Sandwich Ins.' (MEL 587792).

*Labordia triflora* W.F. Hillebr., Fl. Haw. Is., 293. 'Molokai, Sandwich Inseln. leg. Hbd.' (MEL 587795).

## MALVACEAE

*Hibiscus kokio* W. F. Hillebr. Flora 56: 174 (1873). 'Molokai. leg. Hillebrand.' (MEL 587718).

## MENISPERMACEAE

*Cocculus virgatus* W. F. Hillebr., Fl. Haw. Is., 8 = *Cocculus trilobus* (Thunb.) DC. 'Lanai, Sandw. Ins. leg. Hillebrand.' (MEL 587721).

## MYRSINACEAE

*Eubelia pacifica* W.F. Hillebr., Fl. Haw. Is., 282. 'Maui, Sandwich Ins. leg. Hbd.' (MEL 587796).

*Myrsine lauaiensis* W.F. Hillebr., Fl. Haw. Is., 281. 'Lanai, Sandwich In. leg. Hbd.' (MEL 611633).

## NYCTAGINACEAE

*Pisonia sandwicensis* W.F. Hillebr., Fl. Haw. Is., 369. 'Lanai, Sandiweh Ins. leg. Hillebrand.' (MEL 1520475).

## ORCHIDACEAE

*Habenaria holochila* W.F. Hillebr., Fl. Haw. Is., 432 = *Platanthera holochila* (Hillebr.) Kraenzl. 'Kanai, leg. Knudsen.' (MEL 1520529)

## PIPERACEAE

*Peperomia hypoleuca* Miq. b var. *montis eeka* W.F. Hillebr., Fl Haw. Is., 422 = *P. eekana* C.DC. 'West Maui, Sandwich Ins. leg. Hillebrand.' (MEL 1520494).

*Peperomia macraeana* C. DC. b var. *picta* W. F. Hillebr., Fl. Haw. Is., 421 = *P. macraeana* C. DC. 'W. Maui, Sandw. Inseln. leg. Hillebrand.' (MEL 587955).

*Peperomia mauensis* Wawra b var. *parvifolia* W.F. Hillebr., Fl. Haw. Is., 425 = *P. ligustrina* W.F. Hillebr. 'West, Maui, Sandwich I. leg. Hillebrand.' (MEL 587956).

## PITTOSPORACEAE

*Pittosporum cauliflorum* Mann var *fulvum* W.F. Hillebr., Fl. Haw. Is., 25 = *P. confertiflorum* A. Gray. 'Ewa, Waiahua., Oahu. leg. Hillebrand.' (MEL 587722).

*Pittosporum glomertum* var *acutisepala* W.F. Hillebr., Fl. Haw. Is., 23 = *Pittosporum glabrum* Hook. & Arn. 'Niu, Oahu. leg. Hillebrand.' (MEL 587724).

*Pittosporum kauaiense* W.F. Hillebr., Fl. Haw. Is., 25. 'Kauai, leg. Knudsen.' (MEL 587725). Haas (1977: 143) lectotypified this taxon on the description.



## POACEAE

- Agrostis sandwicensis* W.F. Hillebr., Fl. Haw. Is., 515. 'Oahu. leg. Hillebrand.' (MEL 1520483).
- Eragrostis grandis* W.F. Hillebr., Fl. Haw. Is., 528. 'Molokai. Sandw. Ins. leg. Hillebrand.' (MEL 1520486).
- Eragrostis pheloides* W. F. Hillebr., Fl. Haw. Is., 530 = *Eragrostis variabilis* (Gaudich.) W.F. Hillebr. 'Haleakala: Sandw. I.' (MEL 1520487).
- Eragrostis thyrsoidea* W. F. Hillebr., Fl. Haw. Is., 529 = *E. variabilis* (Gaudich.) W. F. Hillebr. 'Oahu. leg. Hillebrand.' (MEL 1520488).
- Eragrostis variabilis* (Gaudich.) b var. *ciliata* W.F. Hillebr., Fl. Haw. Is., 529 = *Eragrostis variabilis* (Gaudich.) Steud. 'Sandwich Inseln.' (MEL 1520523).
- Panicum imbricatum* W.F. Hillebr., Fl. Haw. Is., 501 = *Dichanthelium cynodon* (Reichardt) C.A. Clark & Gould 'Mt Eika: Sandwich. I. leg. Hillebrand.' (MEL 1520489).
- Panicum nephelophilum* Gaudich. var. *xerophilum* W.F. Hillebr. Fl. Haw. Is. 498 = *Panicum xerophilum* (W.F. Hillebr.) Hitchc. 'Maui. Sandwich I. leg. Hillebrand.' (MEL 1520491).

## PRIMULACEAE

- Lysimachia rotundifolia* W.F. Hillebr., Fl. Haw. Is., 284, *nom. illeg.* = *L. hillebrandii* J.D.Hook. ex A.Gray. 'Oahu. leg. Hbd.' (MEL 587803).

## RHAMNACEAE

- Aipluonia ponderosa* W.F. Hillebr., Fl. Haw. Is., 81. 'Molokai. Sandw. In. leg. Hbd.' (MEL 1520399).
- Gouania hillebrandii* Oliver in W.F. Hillebr., Fl. Haw. Is., 83. 'Gullies of Lahaina, Sandwich Ins. leg. Hbd.' (MEL 1520401).

## RUBIACEAE

- Coprosma cymosa* W.F. Hillebr., Fl. Haw. Is., 186. 'Hawaii. leg. Hbd.' (MEL 1520424).
- Coprosma stephanocarpa* W.F. Hillebr., Fl. Haw. Is., 187 = *Coprosma foliosa* A. Gray. 'OH. Maui. Sandwich Ins. leg. Hbd. (MEL 1520413) and 'Maui. Sandwich Ins. leg. Hbd.' (MEL 1520414).
- Kadua foliosa* W.F. Hillebr., Fl. Haw. Is., 164 = *Hedyotis foliosa* (W.F. Hillebr.) Fosberg 'Maui. Sandwich Inseln.' (MEL 1520424).
- Kadua formosa* W.F. Hillebr., Fl. Haw. Is., 165 = *Hedyotis formosa* (W.F. Hillebr.) Fosberg 'Maui. Sandwich Ins. leg. Hbd.' (MEL 1520425).
- Kadua littoralis* W.F. Hillebr., Fl. Haw. Is., 166 = *Hedyotis littoralis* (Hillebr.) Fosberg. 'Molokai. Sandwich. Ins. leg. Hbd.' (MEL 1520429).
- Kadua remyi* W.F. Hillebr., Fl. Haw. Is., 162 = *Hedyotis schlechtendahlana* Steud. 'Lanai. Sandw. Ins.' (MEL 1520432).

## RUTACEAE

- Fagara hawaiiensis* (Hillebr.) Sherff var. *subacuta* Sherff. 'Lanai, Sandw. I.' (MEL 520437). Published by Hillebrand as *Zanthoxylum hawaiiensis* b var. Fl. Haw. Is., 76.
- Pelea molokaiensis* W.F. Hillebr., Fl. Haw. Is., 65. 'Kalea. Molokai. Sandwich Ins. leg. Hillebrand.' (MEL 587806).
- Pelea orbicularis* W.F. Hillebr., Fl. Haw. Is., 67. 'Mount Eka, W. Maui. Sandwich Ins. leg. D. Lydgate.' (MEL 587807)
- Pelea sandwicensis* A. Gray var. *lucens* W.F. Hillebr., Fl. Haw. Is., 66 = *Pelea oahuensis* H. Lévy. 'Oahu. leg. Hillebrand.' (MEL 587811)
- Pelea volcanica* A. Gray b var. *grandifolia* W.F. Hillebr., Fl. Haw. Is., 67 = *Pelea volcanica* A. Gray. 'Hawaii. leg. Hillebrand.' (MEL 587873 & 587874).

## SAPINDACEAE

- Sapindus oahuensis* W. F. Hillebr., Fl. Haw. Is., 85. 'Kalihi. Sandw. Inseln. leg. Hbd.' (MEL 1520574).

## SAPOTACEAE

*Chrysophyllum polyuesicum* W.F. Hillebr., Fl. Haw. Is., 277 = *Nesolumma polyuesicum* (W.F. Hillebr.) Baill. 'Lanai. Sandw. Ins. leg. Hbd.,' (MEL 587814).

*Sideroxylon spathulatum* W.F. Hillebr., Fl. Haw. Is., 277 = *Pouteria saudwiceusis* (A. Gray) Baehni & Degener. 'Lanai. Sandwich Ins. leg. Hbd.' (MEL 587813).

## SOLANACEAE

*Solanum incoupletum* Dunal b var. *maniensis* W.F. Hillebr., Fl. Haw. Is., 305 = *Solanum incoupletum* Dunal. 'Maui. Sandwich Inseln. leg. Hbd.' (MEL 1520575).

## VIOLACEAE

*Viola helioscopia* W.F. Hillebr., Fl. Haw. Is., 17 = *Viola chamissoiana* Ging. 'Makaha. Oahu. leg. Hbd.' (MEL 587733).

*Viola robusta* W.F. Hillebr., Fl. Haw. Is., 16 = *Viola chamissoiana* Ging. subsp. *robusta* (W.F. Hillebr.) W. Wagner, Herbst & Sohmer. 'Molokai. Sandwich I.' (MEL 587734).

## Possible types

## PTERIDACEAE

*Pteris irregularis* Kaulf. b var. *linearis*, W.F. Hillebr., Fl. Haw. Is., 628. The label on the MEL sheet says only "*Pteris irregularis* Kaulf. b. Sandw. Islds." (MEL 1520621)

*Liudsayia alexandri* W.F. Hillebr., Fl. Haw. Is., 622. In the protologue the syntypes were collected by Prof. Alexander and Mr. Lydgate, and by Knudsen. The MEL sheet has no collector noted. (MEL 1520442).

## AMARANTHACEAE

*Nototrichum humile* W.F. Hillebr., Fl. Haw. Is., 373. The label reads 'Wainae. leg. Hillebrand.' In the protologue, Hillebrand cites 'Oahu! Cape Kaena, near the coast.' Waina is near Cape Kaena on the eastern side of the island of Oahu. (MEL 587937).

## RUTACEAE

*Pelea orbicularis* Hillebr., Fl. Haw. Is., 67. The label of the MEL sheet (MEL 587807) reads 'Mount Eika, W. Maui, Sandwich Is. leg. F. Lydgate' The protologue gives this same locality for one of the syntypes, but does not cite Lydgate. In other cases (c.f. *Pittosporum kanaiense*) the collector, if not Hillebrand, was cited. Nonetheless, it is likely that this sheet is a type.

## RUBIACEAE

*Bobea timonioides* Hook., Ic. pl. t. 1070 (1870). The protologue reads 'western end of the Kokala Range, Dr. Hillebrand. n. 186.' The sheet at MEL (MEL 1520405) says only '*Bobea timonioides* [J.D.Hook.] Hbd., Hawaii. leg. Hbr.'

## Types mistakenly reported to be at MEL

The types of the following names are reported by Corn (1983, unpublished), who visited MEL and photographed types of Hillebrand's that she could identify. These photographs have been shared by other workers. In this manuscript Corn reports the following types as being at MEL. These reports are mistaken.

*Peperomia ligustrina* Hillebr. Fl. Haw. Is., 424. Corn lists this name under 'Present Name,' and then has an entry for the 'Name in Hbd, 1888' Under 'Name in Hbd, 1888' Corn lists '*Peperomia maniensis* Wawra b var. *parvifolia*.' Actually, both *P. ligustrina* and *P. maniensis* b var. *parvifolia* are published on the same page. No duplicate of the specimen cited in the protologue of *P. ligustrina*, (i.e. 'W. Maui! Waihee, and forms with shorter and proportionally broader, somewhat obtuse, l-nerved leaves from *Kaanapali*, about 2000 ft. above the sea.') has been located at

MEL. The type of *Peperomia mauiensis* Wawra *b* var. *parvifolia* (q.v.) is erroneously included in Corn's manuscript of type-photos as the type of the former name.

*Cyrtandra malacophylla* C.B. Clarke. Monogr. phan. 5: 227 (1883). The protologue reads "Kauai, Hillebrand, in hb. K." The sheet Corn shows in photo has a label reading 'Maui...', and is in actuality the type of *Cyrtandra parritifolia* (q.v.).

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## Additions to the Hygrocybeae (Fungi, Hygrophoraceae) of Victoria. I.

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### Abstract

Herbarium material from the Jumping Creek Nature Walk of the Warrandyte State Park (Victoria) includes previously described taxa both known from and new to Australia, as well as five undescribed species. Taxa previously known from Australia include *Hygrocybe austropratensis* A.M.Young, *H. cheelii* A.M.Young, *H. leucogloea* A.M.Young, *H. rodwayi* (Massee) A.M.Young and *H. virginea* var. *virginea* (Wulfen : Fr.) P.D.Orton & Watling. Two taxa, *Hygrocybe psittacina* var. *perplexa* (A.H.Sm. & Hesler) Boertm. and *H. virginea* var. *fuscescens* (Bres.) Arnolds, are new records for Australia. Three new species are described: *Hygrocybe arcohostata*, *H. fuhreri* and *H. saltorivula*. The herbarium material also contains three collections which represent two species believed to be new taxa, but for which it is considered there is insufficient material for a valid description and deposition of a suitable type. Descriptions of these two taxa have been provided to assist with further studies of the Jumping Creek taxa.

### Introduction

The Warrandyte State Park is located 25 kilometres north-east of Melbourne (Victoria, Australia) and is on the east bank of the Yarra River. Within the park is the Jumping Creek Nature Walk which passes through various vegetation communities, including the kunzea thickets that contained the fungi examined during this study.

The park receives an annual rainfall of about 600 mm with a greater part of this rainfall occurring during the late autumn and winter months of May to August. Rainfall is somewhat erratic and there can be extended dry periods. The dry, siltstone ridges of the park support open stands of *Eucalyptus polyanthemus* (red box) sometimes mixed with *E. radiata* (narrow-leaved peppermint). The slopes running towards the river are mostly alluvial soils and the trees supported include *E. viminalis* (manna gum), *E. melliodora* (yellow box) and *E. goniocalyx* (long-leaved box). These slopes also have an extensive shrub understorey which includes *Pomaderris prunifolius*, *Correa glabra* and *Kunzea ericoides* (burgan) (Anon. 1997; B.A.Fuhrer, pers. comm.).

Parts of the reserve bordering the nature walk are dominated by very dense thickets of *K. ericoides* about 2–3 metres in height. These thickets replace the usual dominant trees (*Eucalyptus* spp.) which are sometimes slowly killed as an indirect result of the feeding activities of *Manorina melanophrys* (bell miner). The bell miner is a native bird species that feeds on, but also encourages the spread of, lerp insects which can, in large infestations, severely damage eucalypt foliage. The kunzea thickets produce a very extensive and dense canopy which prevents eucalypt germination and re-growth but which also provides a microclimate with ideal conditions for the formation of dense moss and lichen beds on the ground-surface. The moss species present include *Thuidium furfurosus* and *Ptychomnion aciculare* and they in turn provide an ideal habitat for fungal species that require such conditions (B.A.Fuhrer, pers. comm.). The moss beds, with their maintenance of suitable conditions of temperature, moisture and humidity, are the critical factor that allows the Hygrophoraceae to flourish within the park, because the rainfall is too erratic and the normal woodland or forest litter within the park is too exposed to dessication to permit occurrence of the Hygrophoraceae unless there are very unusual climatic conditions.

## Materials and Methods

Fourteen, air-dried collections from the Jumping Creek Nature Walk locality were examined. Field notes accompany each collection, but these are often incomplete and the notes were supplemented using information obtained from very high quality photographs that were made of each collection under natural conditions. Standardised colour codes were not provided with the herbarium collections. All material has been deposited at the National Herbarium of Victoria (MEL).

Descriptions and illustrations are provided for the new taxa and for those species which are either not illustrated in previous papers (Young & Wood 1997; Young 1999) or which require additional text or diagrams as a result of new information. The habit-sketch shows basidiome dimensions. Transverse sections (either drawn or photographed) were not provided with the collection material. The microstructures of the pileus, hymenophoral trama and stipe are generally not depicted because they usually conform to standard forms (Young & Wood 1997). For each illustrated specimen, 20 spores and 10 basidia were selected at random, drawn and measured. Scale bars are provided for all drawings: habit sketches, 10 mm; all microstructures, 10  $\mu\text{m}$ . The derived parameter 'Q' is defined as the quotient of the length divided by the width of the relevant spore or basidium; the mean 'Q' is the quotient of the mean length and width respectively.

This paper lists several species of Hygrophoraceae originally collected and described from Europe for which no types are designated (Boertmann pers. comm.). This problem has already been addressed (Young 2000) and where types for European taxa do not exist, the species concepts of Boertmann (1995) are used.

## Species: Information and Descriptions

**1. *Hygrocybe austropratensis*** A.M.Young, *Austrobaileya* 5: 546 (1999). *Type*: New South Wales. Lane Cove Bushland Park, 33°49'S 151°10'E, 7.vi.1998, R. & E.Kearney s.n. (holotype DAR 73916; isotype BRI).

*Illustration*: Young (1999), p. 546.

*Habitat*: Gregarious or caespitose on soil amongst moss.

*Material examined*: VICTORIA. Warrandyte State Park, 23.v.1996, B.A.Fuhrer 2055 (MEL 2063194).

*Remarks*: The macrocharacters of the Jumping Creek material agree with those of the type description. The swollen stipe base observed in the holotype material is also present in the Victorian collection, suggesting that the characteristic is not peculiar to the Lane Cove collections. A swollen stipe base does not appear in the closely related European *Hygrocybe pratensis* (Pers. : Fr.) Murrill; other characters which also separate *H. pratensis* are discussed in Young (1999). The spores of the Victorian material ( $5.5\text{--}8 \times 4.5\text{--}6 \mu\text{m}$ , mean  $6.8 \times 5.3 \mu\text{m}$ , Q: 1.1–1.5, mean Q: 1.28) are slightly smaller than those of the type ( $6\text{--}8.3\text{--}(9) \times 5\text{--}7.3 \mu\text{m}$ , mean  $7.5 \text{--} 6.3 \mu\text{m}$ , Q: 1.1–1.4, mean Q: 1.2) but the two ranges overlap so extensively that the difference is not considered significant. The basidia of the Jumping Creek collection also show the same smaller size ( $44\text{--}59 \times 6\text{--}8 \mu\text{m}$ , mean  $50.7 \times 6.8 \mu\text{m}$ , Q: 6.1–8.8, mean Q: 7.48) compared with the type ( $53\text{--}69 \times 6\text{--}8 \mu\text{m}$ , mean  $62.0 \times 6.8 \mu\text{m}$ , Q: 6.6–10.2(–12.6), mean Q: 9.20) but again the overlap is considerable and the differences are not considered significant. Only the type collection was previously known.

**2. *Hygrocybe cheelii*** A.M.Young, *Austrobaileya* 5: 547 (1999). *Type*: New South Wales. Gladesville, 17.vi.1916, J.B.Cleland s.n. (holotype AD 3418). *Cantharellus lilacinus* Cleland & Cheel, *Trans. & Proc. Roy. Soc. S. Australia* 43: 271 (1919). *Type*: New South Wales. Gladesville, 17.vi.1916, J.B.Cleland s.n. (holotype AD 3418). *Camarophyllus*

*lilacinus* (Cleland & Cheel) E.Horak, *New Zealand J. Bot.* 28: 203 (1990) non *Hygrocybe lilacina* (C.Laest. ex P.Karst.) M.Moser, *Die Röhrlinge und Blätterpilze (Agaricales)* 3 ed., 64 (1967).

*Illustrations*: Young (1999), p. 547; Willis (1963), plate 9, fig.1 as *Cantharellus lilacinus*; Cleland & Cheel (1919), Plate 29, fig.1.

*Habitat*: Gregarious amongst leaf mould and moss under *Kunzea ericoides*.

*Material examined*: VICTORIA. Warrandyte State Park, 4.vi.1995, B.A.Fuhrer1937 (MEL 2063188).

*Remarks*: The macrocharacters of the basidiomes in MEL 2063188 conform very closely to those of the holotype description (Cleland & Cheel 1919) and the material previously described from the Lane Cove Bushland Park (Young 1999). The differences in spore dimensions are insignificant: the Jumping Creek Nature Walk material has spores that measure  $7-10 \times 4.5-5.5(-6.5)$   $\mu\text{m}$ , mean  $8.4 \times 5.4$   $\mu\text{m}$ , Q: 1.3-1.8, mean Q: 1.56; the holotype description gives the spores as  $7-8.5 \times 4.5-5.5$   $\mu\text{m}$ , and re-examination of the type gave spores measuring  $6.0-8.5 \times 4.5-6.0$   $\mu\text{m}$ , mean  $7.2 \times 5.5$   $\mu\text{m}$ , Q: 1.2-1.7 and mean Q: 1.5.

The holotype collection is in very poor condition due to insect attack and original preservation. Obtaining critical information from this material is quite difficult especially since almost nothing remains of the lamellae. For these reasons, two collections, B.A. Fuhrer 1937, (MEL 2063188), and *hb young 2118* (BRI) are here nominated as exemplar material as each is considered identical to the holotype in all significant respects (Young 1999). The collection in the Queensland Herbarium (BRI) is particularly significant as it contains material that was collected within approximately 10 kilometres of the original 1916 collection of the holotype at Gladesville, New South Wales.

**3. *Hygrocybe leucogloea*** A.M.Young, in Young & Wood, *Austral. Syst. Bot.* 10: 976 (1997). *Type*: New South Wales. Mt. Wilson, 33°30'S 150°22'E, 29.iv.1989, A.E.Wood s.n. (holotype UNSW 89/87).

*Illustration*: Young & Wood (1997), p. 984.

*Habitat*: Gregarious or caespitose in moss amongst litter.

*Material examined*: VICTORIA. Warrandyte State Park, 23.v.1996, B.A.Fuhrer 2060 (MEL 2063192).

*Remarks*: The first Victorian record of *Hygrocybe leucogloea* was from the Black Range State Forest (Young 2000). The Jumping Creek Nature Walk collection has spores that measure  $6-7(-8) \times 4-5(-5.5)$   $\mu\text{m}$ , mean  $6.7 \times 4.5$   $\mu\text{m}$ , Q: 1.3-1.7, mean Q: 1.50, a slightly smaller mean and reduced upper range when compared with spores of the holotype collection [ $(6.3-6.5-7.9(-8.5) \times 4.0-5.6$   $\mu\text{m}$ , mean  $7.2 \times 4.8$   $\mu\text{m}$ , Q: 1.2-1.7, mean Q: 1.50]. Although medallion clamps are present on the hyphae of the ixotrichoderm in the holotype collection, none were found on the relevant hyphae of the Jumping Creek Nature Walk collection although clamps were abundant. This difference is thought to be part of a morphological range of basidiome variations likely to be encountered in this taxon.

**4. *Hygrocybe psittacina* var. *perplexa*** (A.H.Sm. & Hesler) Boertm., *Fungi of Northern Europe*. 1: 82 (1995). *Type*: U.S.A. Michigan, Cheboygan County, T.E.Brooks & A.H.Smith 21491 (holotype MICH 10924, n.v.). *Hygrophorus perplexus* A.H.Sm. & Hesler, *Sydowia* 8: 328 (1954). *Hygrocybe perplexa* (A.H.Sm. & Hesler) Arnolds, *Persoonia* 12: 477 (1985).

*Illustration*: Boertmann (1995), p. 83.

*Pileus* 15–30 mm, orange-brown to reddish brown but darker at the centre, convex becoming plane or upturned but then retaining an umbo at the centre, very glutinous, strongly striate at the margins and for up to one-third of the pileal diameter, margins paler and a little crenulate. *Lamellae* adnate to narrowly adnate, pinkish buff, thick, distant, margins concolorous and even. *Stipe* 30–45 × 2–3 mm, orange-red but paler at the apex, smooth, cylindrical, very glutinous.

*Spores* 6–8(–9) × 4–5.5 µm, mean 7.0 × 4.8 µm, Q: 1.2–1.6(–1.8), mean Q: 1.46, broadly ellipsoid to obovoid or sub-lacrymoid or occasionally sub-globose, smooth, hyaline, thin-walled, inamyloid. *Basidia* (27–)31–47 × 7–9.5 µm, mean 38.2 × 8.0 µm, Q: 3.9–6.2, mean Q: 4.78, (2-) 4-spored, clavate, hyaline, thin-walled, clamped and sometimes of medallion form. *Cystidia* absent. *Hymenophoral trama* regular in the upper two-thirds of the lamellae but sub-regular to irregular in the lower one-third nearest the margins; regular trama composed of short, parallel, thin-walled, hyaline elements 33–35 × 5–22 µm, clamps present; sub-regular to irregular trama composed of ellipsoid to sub-globose, hyaline, thin-walled elements 15–5 × 7–3.5 µm, clamps not seen. *Lactifers* may be present in the regular trama section and appear as meandering, contorted, hyaline hyphae 3–5 µm diameter, but do not exhibit the typical very high refractive index and may be overlooked. *Pileipellis* a very well defined ixotrichoderm 50–120 µm in thickness and composed of thin-walled, hyaline, septate, cylindrical hyphae 1.5–3.5 µm diameter, usually with apices that are rounded or slightly swollen, clamped and sometimes of

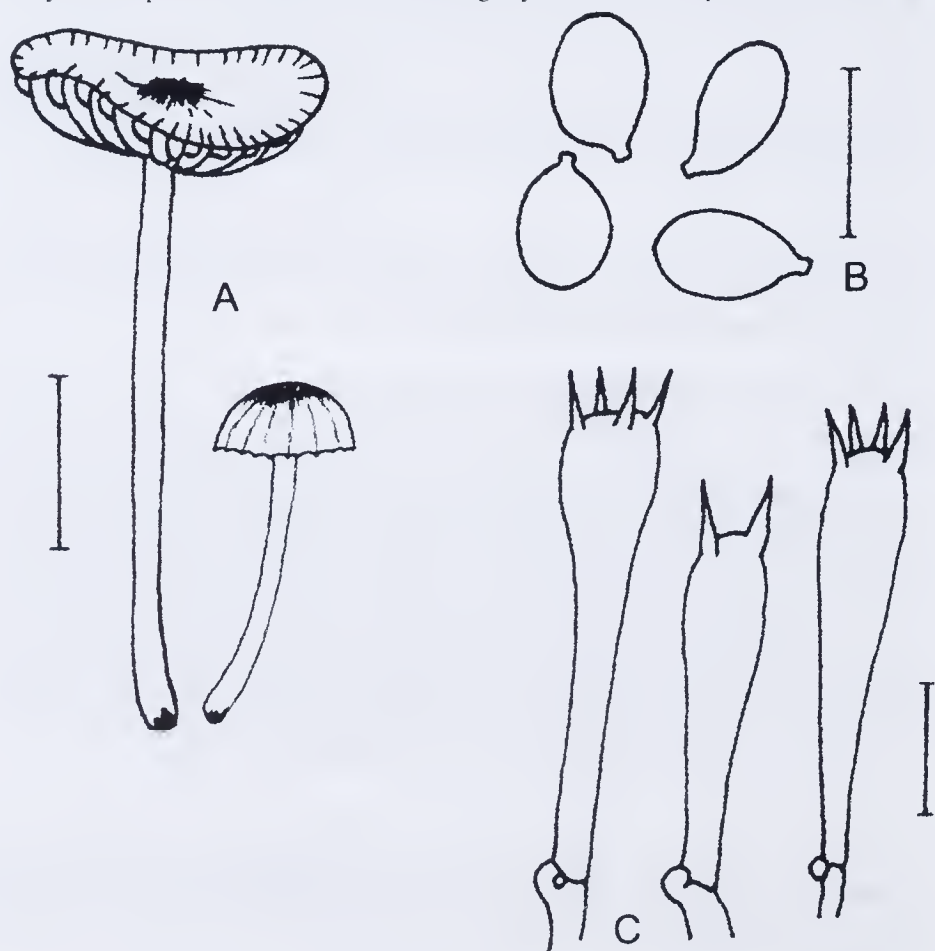


Figure 1. *Hygrocybe psittacina* var. *perplexa*. A habit sketch; B spores; C basidia.



medallion form. *Stipitipellis* a well developed ixotrichoderm composed of hyaline, thin-walled, septate hyphae 1.5–5 mm diameter, medallion clamps usually present. (Fig. 1)

*Habitat*: Gregarious in moss and litter under *Kunzea ericoides*.

*Material examined*: VICTORIA. Warrandyte State Park, 10.vi.1994, B.A.Fuhrer 1994 (MEL 2063197).

*Remarks*: The material in MEL 2063197 agrees almost exactly with the description of the taxon given in Boertmann (1995) which has spores measuring  $(6-7-8.5(-9) \times (4-4.5-5.5(-6) \mu\text{m})$ , Q: 1.4–1.9 mean Q: 1.5–1.6, and basidia measuring  $36-50 \times 7-8 \mu\text{m}$  which have medallion clamps at their bases. Basidiomes of *Hygrocybe psittacina* var. *perplexa* are readily separated from brownish red basidiomes of *H. graninicolor*, because the latter have umbilicate pilei and arcuate or decurrent lamellae with cheilocystidia embedded in a glutinous thread on their margins.

This is the first confirmed record of this Northern Hemisphere taxon for Australia. The species was first described from North America but is also known from Europe (Boertmann 1995; Arnolds 1990) and Japan (Imazeki, Otani & Hongo 1988).

**5. *Hygrocybe rodwayi*** (Masse) A.M.Young, in A.M.Young & A.E.Wood, *Austral. Syst. Bot.* 10: 923 (1997). *Hygrophorus rodwayi* Masse, *Bull. Misc. Inform. Kew* 1899: 178 (1899). *Type*: Tas. Kingston Rd. (nr. Hobart), undated, L.Rodway 137 (holotype K). *Camarophyllus rodwayi* (Masse) Monks & A.K.Mills in Banks *et al.* (eds), *Aspects of Tasmanian Botany – A Tribute to Winifred Curtis* 13 (1991).

*Illustrations*: Young & Wood (1997), p. 925; Fuhrer & Robinson (1992), p. 39.

*Habitat*: Gregarious in moss.

*Material examined*: VICTORIA. Warrandyte State Park, 23 May 1996, B.A.Fuhrer 2059 (MEL 2063193).

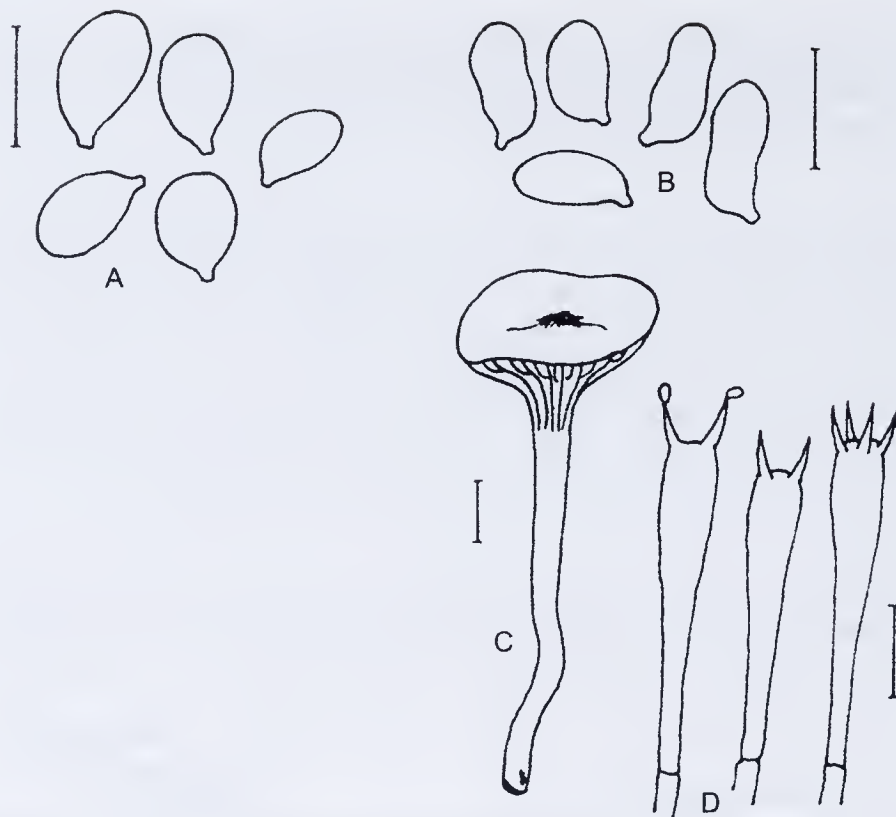
*Remarks*: This collection has sub-globose to globose spores measuring  $(4.5-5.5-6(-7) \times (4-4.5-5.5 \mu\text{m})$ , mean  $5.7 \times 4.8 \mu\text{m}$ , Q: 1.0–1.4, mean Q: 1.18. This agrees very well with the holotype collection, which has similar spores measuring  $5-7 \times 4-6 \mu\text{m}$ , mean  $5.8 \times 5.1 \mu\text{m}$ , Q: 1.0–1.3(–1.4), mean Q: 1.15. The photographic material accompanying the Warrandyte collection depicts basidiomes that have a strong resemblance to the other common white taxon, *Hygrocybe virginea* var. *virginea* (Wulfen : Fr.) P.D.Orton & Watling, but the two are always separable microscopically because *H. virginea* var. *virginea* has much larger, ellipsoid spores measuring  $8-11(-12) \times 5-8 \mu\text{m}$ . *Hygrocybe rodwayi* occurs in eastern Australian forests from the Sydney region to Tasmania (Young & Wood 1997; Young 2000).

**6. *Hygrocybe virginea*** (Wulfen : Fr.) P.D.Orton & Watling, *Notes Roy. Bot. Gard. Edinburgh* 29: 132 (1969). *Agaricus virgineus* Wulfen, in Jacq., *Misc. austr.* 2: 104 (1781). *Type*: none designated. *A. virgineus* Wulfen : Fr., *Syst. mycol.* 1: 100 (1821); *Hygrophorus virgineus* (Wulfen : Fr.) Fr., *Epicr.* 327 (1838); *Camarophyllus virgineus* (Wulfen : Fr.) P.Kumm., *Führ. Pilzk.* 117 (1871).

*Agaricus niveus* Scop., *Fl. carn.*, Ed. 2, 2: 430 (1772). *Type*: none designated. *A. virgineus* var. *niveus* (Scop.) Fr., *Syst. mycol.* 1: 100 (1821); *Hygrophorus niveus* (Scop.) Fr., *Epicr.* 327 (1838); *Camarophyllus niveus* (Scop.) Wunsche, *Pilze* 115 (1877).

#### Key to varieties of *Hygrocybe virginea*

1. Pileus pure white; spores ellipsoid, rarely constricted.....6a. var. *virginea*
1. Pileus brown at the centre; spores ellipsoid, often cylindrical and constricted .....  
.....6b. var. *fuscescens*



**Figure 2.** *Hygrocybe virginea*, var. *virginea*. **A** spores, var. *fuscescens*. **B** spores; **C** habit sketch; **D** basidia.

**6a. var. *virginea*** (Fig. 2)

*Illustrations:* Young & Wood (1997), p. 929; Boertmann (1995), p. 49.

*Habitat:* Gregarious in moss under *Kuuzea ericoides*.

*Material examined:* **VICTORIA.** Warrandyte State Park, 10.vi.1995, B.A.Fuhrer 1942 (MEL 2063190); Warrandyte State Park, 10.vi.1995, B.A.Fuhrer 1943 (MEL 2063198).

*Remarks:* These collections have macroscopic characters that agree very closely with those previously described for Australian material (Young & Wood 1997; Young 1999). There are minor microscopic variations. Collection MEL 2063190 contains basidiomes with 2-spored basidia and spores that display occasional small constrictions measuring  $8-11(-12) \times 5-8 \mu\text{m}$ , mean  $9.6 \times 6.4 \mu\text{m}$ , Q: 1.2-1.8, mean Q: 1.50; clamps are absent throughout the basidiome. Collection MEL 2063198 contains basidiomes that have 4-spored basidia and spores measuring  $6-8(-9) \times 3.5-6.5 \mu\text{m}$ , mean  $7.3 \times 4.6 \mu\text{m}$ , Q: 1.3-1.8(-1.9), mean Q: 1.6. Basidiomes with either or both 2-spored and 4-spored basidia are reported in Boertman (1995) and the Australian material agrees fully with that description.

Previous papers (Young & Wood 1997; Young 1999) recorded this taxon as *Hygrocybe virginea* (Wulfen : Fr.) P.D.Orton & Watling. The Jumping Creek collections conform very closely with European descriptions of var. *virginea*.

**6b. var. *fuscescens*** (Bres.) Arnolds, *Persoonia* 12: 477 (1985). *Type:* none designated. *Hygrophorus uivens* var. *fuscescens* Bres., *Iconogr. mycol.* 7: pl. 330 (1928).

*Illustration:* Boertmann (1995), p. 51.

*Spores* 8–11 × 4–6 µm, mean 9.5 × 4.9 µm, Q: 1.5–2.3, mean Q: 1.93, long-ellipsoid to cylindrical and often strongly constricted. *Basidia* 2-spored. The remainder of the microscopic characters conform with var. *virginea*. (Fig. 2)

*Habitat*: Gregarious amongst leaf litter and moss.

*Material examined*: VICTORIA. Warrandyte State Park, 4 June 1995, B.A.Fuhrer 1936 (MEL 2063191).

*Remarks*: Macroscopically, this taxon differs from var. *virginea* only in that the centre of the pileus is distinctly brown-tinted. Microscopically, the spores differ as presented in the key. This is the first record of this taxon for Australia. Its characters agree very well with the those in the description by Boertmann (1995).

## 7. *Hygrocybe arcohastata* A.M.Young, sp. nov.

Pileus 20–40 mm latus, atro-olivaceo-viridis deinde aurantiacus vel aurantiaco-ruber, conicus dein lato-conicus vel applanatus vel umbonatus, glaber, sub-viscidus, ad marginem aequalis vel crenulatus, striatus. Lamellae adnatae vel arcuatae, virello-flavae dein subaurantiacae, ad marginem concolorae. Stipes 20–40 × 2–4 mm, super sub-viridis, sub-malvinus, cylindricus, glaber, siccus, ad basim sub-aurantiacus. Sporae 7.5–9.5 × 4.5–6 µm, Q: 1.4–1.8(–2.0), ellipsoideae, hyalinae. Basidia 38–50 × 6–9(–10.5) µm, Q: (3.6–)4.2–6.5, 4-spores, ad basim fibulata medallionae. Cystidia nulla. Trama hymenophoralis regularis, haud fibulata. Epicutis pilei sub-ixocutem formans; hyphae cuticularis hastatae, pigmentae. Gregaria vel caespitosa in musco sylvestri.

*Type*: Victoria. Warrandyte State Park, 24.v.1996, B.A.Fuhrer 2064 (holotype MEL 2063201).

*Pileus* 20–40 mm., at first deep olive-green but dark purple-tinted at the centre and yellow-tinted at the margin, changing to orange or orange-red with the colour change completed before the pileus is fully expanded; conical becoming broadly conical and finally more or less plane with a distinct umbo, smooth, slightly viscid, margin even to crenulate and striate. *Lamellae* adnate with a decurrent tooth or arcuate, greenish yellow becoming orange-tinted with age, margins even and concolorous. *Stipe* 20–40 × 2–4 mm; pale green near the lamellae, mauve-tinted in the middle section and orange-tinted towards the base; more or less cylindrical but a little tapered at the base; smooth, dry. Dried material becomes brownish pink to orange.

*Spores* 7.5–9.5 × (4.5–)5–6 µm, mean 8.5 × 5.3 µm, Q: 1.4–1.8(–2.0), mean Q: 1.60, ellipsoid, smooth, hyaline, thin-walled, inamyloid. *Basidia* 38–50 × 6–9(–10.5) µm, mean 44.7 × 8.3 µm, Q: (3.6–)4.2–6.5, mean Q: 5.32, 4-spored, with medallion clamps. *Cystidia* absent. *Hymenophoral trama* regular and composed of cylindrical, thin-walled, hyaline, inflated and ellipsoid or moniliform elements 19–125 × 4.5–20.5 µm, clamps absent. *Pileipellis* a weak ixocutis of repent, cylindrical, hyaline, septate hyphae 2–4.5 µm diameter, with spear-like, tapered, acute, pigment-encrusted apices; clamps absent. *Stipitipellis* a cutis of repent, cylindrical, thin-walled, hyaline, septate hyphae 1.5–5.5 µm diameter, clamps absent, pigment granules often encrusted on hyphal walls. (Fig. 3)

*Habitat*: Gregarious or caespitose amongst moss in eucalypt woodland.

*Material examined*: Known only from the type.

*Remarks*: The absence of clamps throughout the basidiome (except at the bases of the basidia where they are of medallion form) indicates that this taxon belongs in sub-genus *Humidicutis* Singer. *Hygrocybe arcohastata* does not approach any European or North American taxa, but it is close to a group of three New Zealand species, *Hygrocybe conspicua* E.Horak, *H. luteovirens* E.Horak. and *H. multicolor* (Berk. & Broome) E.Horak (Horak 1990). *Hygrocybe conspicua* can be separated from *H. arcohastata* because the former has a brilliant orange pileus and similarly coloured lamellae as well as smaller spores (6–7 × 4–4.5 µm). *Hygrocybe multicolor* also has smaller spores (5.5–7 × 4–5 µm)

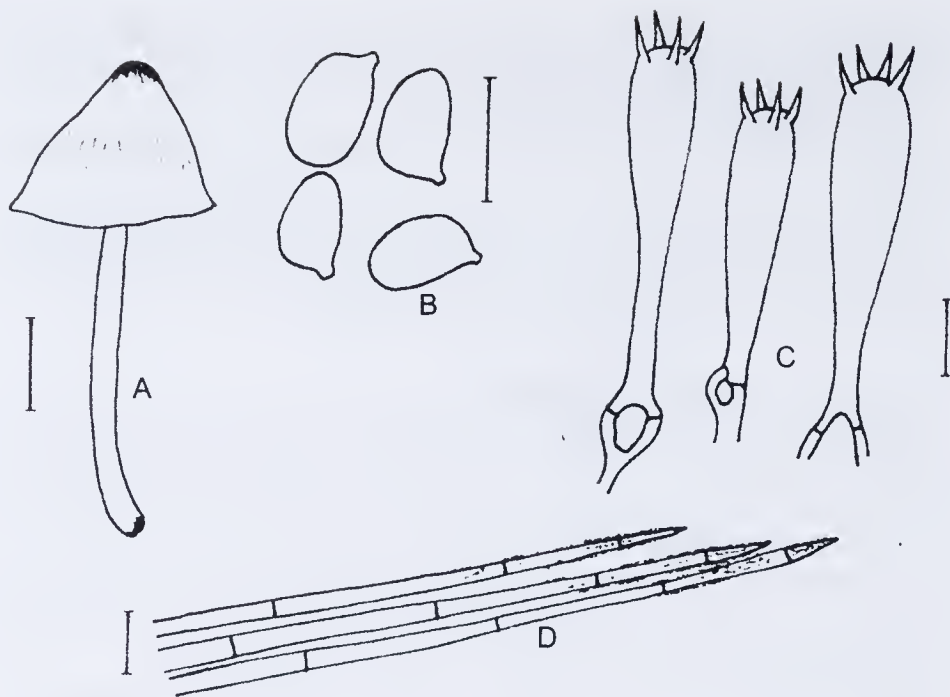


Figure 3. *Hygrocybe arcohastata*. A habit sketch; B spores; C basidia; D cuticular hyphae.

and both pileus and lamellae are olive-green becoming bluish green with age. *Hygrocybe luteovirens* has spores that have a lower upper limit to their range of length and are narrower ( $6-8 \times 3.5-4.5 \mu\text{m}$ ), has olive-green pilei that gradually change to yellow, yellow-brown, brown or reddish brown with age rather than the intense orange or orange-red of *H. arcohastata*, and medallion clamps that have the structure of a normal clamp with a central opening rather than the extremely large 'dough-nut' shape of the medallion clamps found in *H. arcohastata*.

The only other taxon that is similar is the Japanese species *Hygrophorus olivaceoviridis* Hongo (Hongo 1967). This differs in that the pilei remain olive-green, the lamellae are yellowish and the basidia are much smaller ( $34-40 \times 7.5-8 \mu\text{m}$ ).

*Etymology*: Latin, *arcus* – a rainbow; Latin, *hastatus* – armed with a spear; referring to the numerous colours exhibited by this taxon and the long, spear-like endings of the cuticular hyphae.

#### 8. *Hygrocybe fuhreri* A.M.Young, sp. nov.

Pileus 10–20 mm latus, aurantiaco-brunneus, convexus deinde umbilicatus, glaber, siccus, ad marginem striatus, crenulatus dein aequalis. Lamellae decurrentes, sub-aurantiaco-bubalinae, distantes, ad marginem concolorae. Stipes 30–45  $\times$  2–4.5 mm, sub-aurantiaco-flavus, glaber, siccus, cylindricus, cavus. Sporae 8–10.5  $\times$  4–4.5 (–6)  $\mu\text{m}$ , Q: 1.7–2.1, ellipsoideae vel cylindricae, hyalinae, aliquot constrietae. Basidia (40–)49–59  $\times$  5.5–7  $\mu\text{m}$ , Q: 7.1–8.7, 4-sporea, fibulata. Cystidia nulla. Trama hymenophoralis regularis, fibulata. Epicutis pilei cutis formans. Gregaria in humo vel musco sylvestri.

*Type*: Victoria, Warrandyte State Park, 23.v.1996, B.A.Fuhrer 2054 (holotype MEL 2063199).

*Pileus* 10–20 mm, reddish orange to orange-brown and darker at the centre, convex and umbilicate, dry, smooth, margin striate, even and a little crenulate. *Lamellae* decurrent, pale orange-buff, distant, margins even and concolorous. *Stipe* 30–45  $\times$  2–4.5 mm, orange-yellow, cylindrical but tapered at the base, dry, smooth, hollow, often sinuous.



*Spores*  $8\text{--}10.5 \times 4\text{--}5.4(-6) \mu\text{m}$ , mean  $9.0 \times 5.1 \mu\text{m}$ ,  $Q: 1.7\text{--}2.1$ , mean  $Q: 1.78$ , ellipsoid to cylindrical, a majority showing some constriction, smooth, hyaline, inamyloid. *Basidia*  $(40\text{--})49\text{--}58 \times 5.5\text{--}7 \mu\text{m}$ , mean  $57.7 \times 6.7 \mu\text{m}$ ,  $Q: 7.1\text{--}8.7$ , mean  $Q: 7.69$ , 4-spored, clamped. *Cystidia* absent. *Hymenophoral trama* regular and composed of short, cylindrical to inflated-ellipsoid, hyaline, thin-walled, elements  $22\text{--}83 \times 4.5\text{--}13 \mu\text{m}$ , clamps present. *Pileipellis* a cutis of repent, cylindrical, hyaline, thin-walled, septate hyphae  $2\text{--}5.5 \mu\text{m}$  diameter, clamps present. *Stipitipellis* a cutis of repent, cylindrical, hyaline, thin-walled, septate hyphae  $1.7\text{--}4.2 \mu\text{m}$  diameter, clamps present. (Fig. 4)

*Habitat*: Gregarious in moss and litter in eucalypt woodland.

*Material examined*: Known only from the type.

*Remarks*: The regular hymenophoral trama composed of short elements places this species in subgenus *Pseudohygrocybe* M.Bon. No taxon from either Sri Lanka (Pegler 1986) or North America (Hesler & Smith 1963) approaches *H. fuhreri* closely. The only European species which shares some similar characteristics according to both Arnolds (1990) and Boertman (1995) is *Hygrocybe constrictospora* Arnolds; however, that species has bright red pilei which do not (or rarely) become depressed or umbilicate, bright yellow stipes, smaller basidia ( $35\text{--}45 \times 5\text{--}7.5 \mu\text{m}$ ) and spores that exhibit very strong constrictions rather than the minor constrictions that are present in *H. fuhreri*. Several orange and/or yellow species from New Zealand (Horak 1990) approach *H. fuhreri* but each is readily separated: *Hygrocybe elegans* E.Horak has a trichoderm on the pileus; *Hygrocybe procera* has much larger spores ( $11\text{--}17 \times 7\text{--}10 \mu\text{m}$ ); *Hygrocybe cerinolutea* E.Horak does not have constricted spores and the pileus does not become umbilicate; and *Hygrocybe blanda* E.Horak has much smaller spores ( $5.5\text{--}7 \times 4\text{--}4.5 \mu\text{m}$ ).

*Etymology*: named after Mr B.A. Fuhrer of Ringwood, Melbourne Victoria; photographer, naturalist and mycologist.

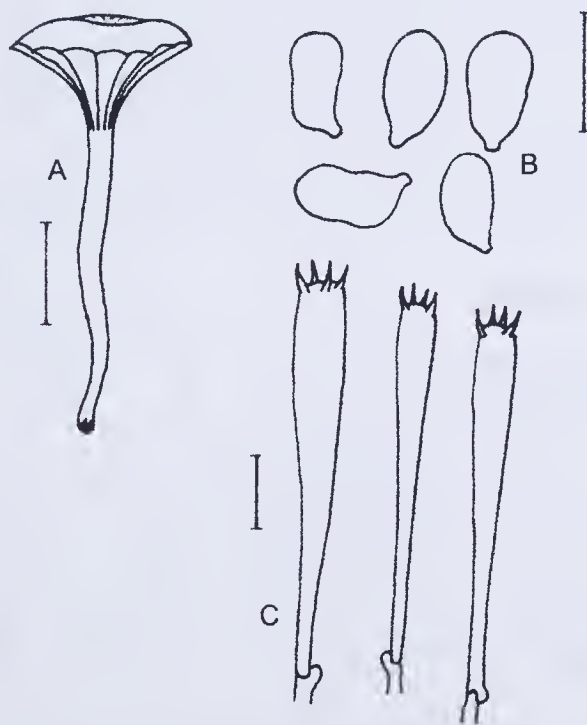


Figure 4. *Hygrocybe fuhreri*. A habit sketch; B spores; C basidia.

**9. *Hygrocybe saltorivula* A.M.Young, sp. nov.**

Pileus 20–35 mm latus, aurantiacus vel aurantiaco-rubus, conicus deinde umbonato-applanatus, viscidus, ad marginem sub-striatus, sub-flavus. Lamellae adnatae, ventricosae, aurantiaco-rosae, ad marginem sub-flavae. Stipes 30–40 × 2–4 mm, aurantiaco-roseus vel aurantiacus, glaber, lubricus deinde siccus, cavus. Sporae 7.5–9(–9.5) × 4–5 µm, Q: 1.6–2.2, ellipsoideae vel cylindricae, hyalinae, aliquot constrictae. Basidia 37–49 × 5.5–9 µm, Q: 5.2–5.7, 4-spora, fibulata. Cystidia nulla. Trama hymenophoralis regularis, fibulata. Epicutis pilei ixotrichoderm formans. Gregaria in musco sylvestri.

*Type:* Victoria, Warrandyte State Park, 23.v.1996, B.A.Fuhrer 2053 (holotype MEL 2063200).

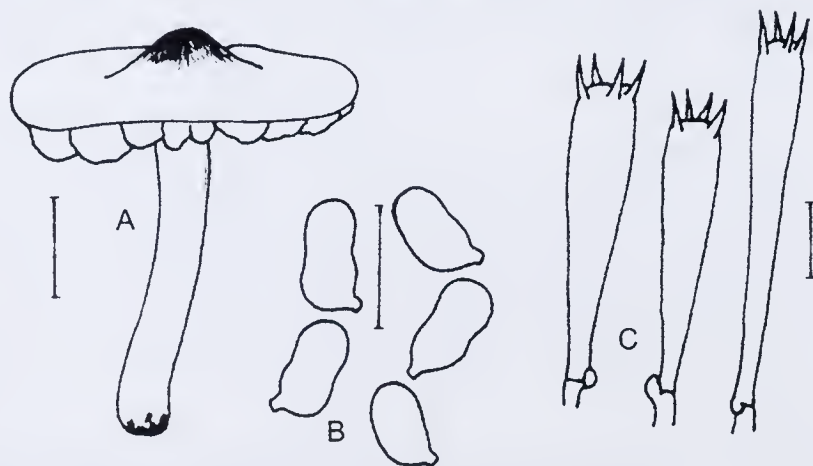
*Pileus* 20–35 mm, orange, orange-red to cherry-red, broadly conical becoming plane but with a central umbo, viscid, smooth, margins even, a little striate and slightly yellowish. *Lamellae* adnate, ventricose, orange-pink, margins yellowish or a little paler. *Stipe* 30–40 × 2–4 mm, orange-pink or orange especially when older, smooth, slippery or soon dry, cylindrical, hollow.

*Spores* 7.5–9(–9.5) × 4–5 µm, mean 8.3 × 4.4 µm, Q: 1.62.2, mean Q: 1.89, ellipsoid to cylindrical, hyaline, smooth, thin-walled, inamyloid, a majority strongly constricted. *Basidia* 37–49 × 5.5–9 µm, mean 42.7 × 7.2 µm, Q: 5.2–7.2, mean Q: 5.95, 4-spored, clavate, thin-walled, hyaline, clamped. *Cystidia* absent. *Hymenophoral trama* regular and composed of cylindrical, ellipsoid or moniliform elements which are hyaline, thin-walled 37–110 × 7–30 µm, clamps present: lactifers present as highly refractive, winding, thin-walled, hyaline hyphae 1.5–4 µm diameter. *Pileipellis* an ixotrichoderm up to 50 µm deep, composed of hyaline, thin-walled, clamped hyphae 2.5–4 µm diameter, apices often swollen. *Stipitipellis* a weak ixocutis of repent, hyaline, thin-walled, clamped, partially gelatinised hyphae 1–3.5 µm diameter. (Fig. 5)

*Habitat:* Gregarious amongst deep moss in eucalypt woodland.

*Material examined:* Known only from the type.

*Remarks:* The regular hymenophoral trama composed of short elements places this species in subgenus *Pseudohygrocybe* M.Bon. The basidiomes of *Hygrocybe saltorivula* strongly resemble mature fruiting bodies of *Hygrocybe cerasinomutata* A.M.Young which change from cherry-red to golden orange (Young & Wood 1997); however, the latter is easily separated microscopically by its very regular hymenophoral trama of tubular, aseptate elements. *Hygrocybe saltorivula* also approaches *Hygrocybe julietae* (G.Stev.) E.Horak from New Zealand but that species has a convex pileus, arcuate lamellae and



**Figure 5.** *Hygrocybe saltorivula*. A habit sketch; B spores; C basidia.

much smaller spores ( $6-8 \times 3-3.5(-4) \mu\text{m}$ ). The South American species *Hygrocybe araucana* Singer differs by having a convex pileus and a dry cutis (Horak 1979).

*Etymology*: Latin, *saltus* – to jump; Latin, *rivulus* – a small stream; from the name of the type locality.

### Taxa with Limited Collections

During this study, three collections made from the Jumping Creek Nature Walk area were considered to be new species but were found to consist of only two or three basidiomes which is considered insufficient material for a valid description and deposition of a suitable type. These collections have provided well defined characters for two taxa. The descriptions are provided here to facilitate further studies.

#### *Hygrocybe* sp. JCR1

*Pileus* 10–20 mm, pale orange, luteous or slightly ochre tinted yellow, strongly viscid to near glutinous, convex with a central umbo or umbonate, smooth, margins somewhat crenulate. *Lamellae* deeply decurrent, white or pale cream-coloured, margins concolorous. *Stipe* 30–40  $\times$  2–4 mm, whitish to pale yellow or pale orange but paler or near white near lamellae, smooth, dry, tapered downwards.

*Spores*  $8.5-11(-11.5) \times 4-6 \mu\text{m}$ , mean  $9.8 \times 5.1 \mu\text{m}$ , Q: 1.7–2.5, mean Q: 1.91, ellipsoid to lacrymoid or subcylindrical, hyaline, thin-walled, inamyloid; subcylindrical spores may occasionally be slightly constricted. *Basidia*  $(28-37-49(-52) \times 4.5-7 \mu\text{m}$ , mean  $43.3 \times 5.6 \mu\text{m}$ , Q: 5.5–10.3, mean Q: 7.68, 2-spored with scattered 1-spored basidia, clamps absent. *Cystidia* absent. *Hymenophoral trama* irregular and composed of hyaline, thin-walled, cylindrical, septate, often branching hyphae  $24-78(-100) \times 2-5(-8.5) \mu\text{m}$ , clamps absent. *Pileipellis* a well developed, loose ixocutis or reduced ixotrichoderm composed of repent to loosely interwoven, cylindrical, hyaline, thin-walled, septate hyphae  $1-5 \mu\text{m}$  diameter, clamps absent. *Stipitipellis* a cutis composed of repent, cylindrical, hyaline, thin-walled, septate hyphae  $1-3.5 \mu\text{m}$  diameter, clamps absent. (Fig. 6)

*Habitat*: Gregarious in moss under *Kunzea ericoides*.

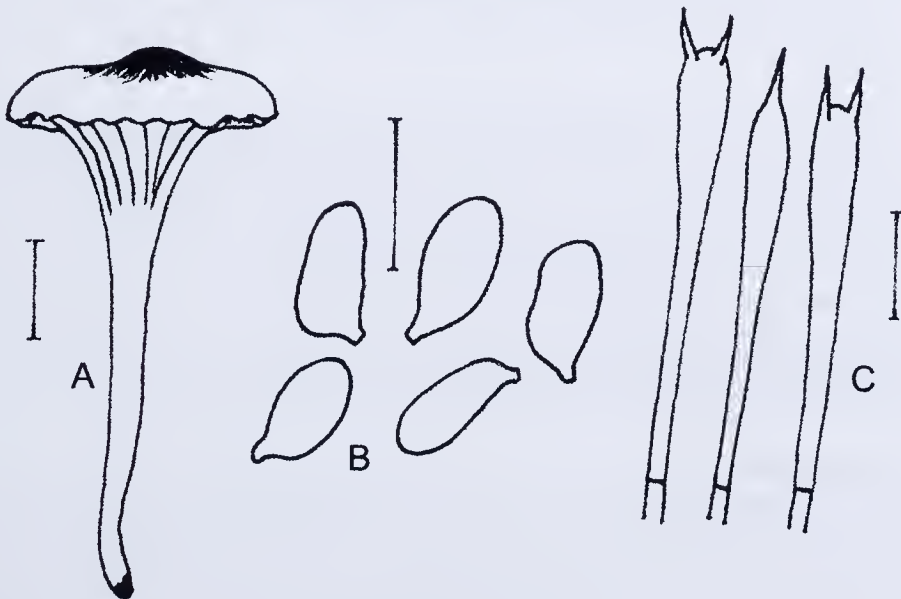


Figure 6. *Hygrocybe* sp. JCR1. A habit sketch; B spores; C basidia.

*Material examined:* VICTORIA. Warrandyte State Park, 10.vi.1995, B.A.Fuhrer 1941 (MEL 2063189); Warrandyte State Park, 10.vi.1995, B.A.Fuhrer 1945 (MEL 2063196).

*Remarks:* This species should be very easy to recognise in any future study since highly glutinous pilei in sub-genus *Cuphiophyllus* (defined by an irregular hymenophoral trama) appear to be uncommon.

### *Hygrocybe* sp. JCR2

*Pileus* 10–20 mm, bright scarlet, fading a little with age, obtusely conical to conical, dry (possibly developing a slightly lubricous surface during maturation) and may appear very finely squamulose in dry conditions; margins striate, yellowish and even to sub-crenulate. *Lamellae* broadly adnate and often with decurrent tooth, buff pink, margins concolorous and even. *Stipe* 30–40 × 3–4 mm, orange-yellow with or without pink tints, cylindrical, dry, hollow, smooth but a fine pruinose, yellowish layer more or less covering the stipe surface when immature but becoming more scattered and flocculose with maturity.

*Spores* 8.5–11(–11.5) × 5–6(–7.5) µm, mean 9.7 × 5.7 µm, Q: (1.3–)1.4–1.9(–2.0), mean Q: 1.69, ellipsoid to obovoid or sub-cylindrical, smooth, hyaline, thin-walled, inamyloid; sub-cylindrical spores may occasionally exhibit small but distinct constrictions. *Basidia* 42–50 × 8–9.5 µm, mean 47.0 × 8.8 µm, Q: 4.9–6.3, mean Q: 5.38, 4-spored, clamped. *Cheilocystidia* and *pleurocystidia* absent. *Hymenophoral trama* regular and composed of a mixture of cylindrical and inflated moniliform elements which are hyaline, thin-walled, septate 30–100 × 5–27 µm, clamps present; lactifers occasionally present as highly refractive, branching, often contorted hyphae 4–8.5 µm diameter. *Pileipellis* a cutis of repent, hyaline, thin-walled, septate, cylindrical and somewhat inflated hyphae 3–9 µm diameter, overlying a subcuticle of moniliform elements similar to those of the hymenophoral trama; lactifers similar to those of the hymenophoral trama present in the subcuticular layer. *Stipitipellis* a cutis of hyaline, thin-walled, repent, cylindrical, septate hyphae, 2.5–5 µm diameter, clamps present. The cuticular hyphae exhibit some weak gelatinisation. *Caulocystidia* present as hyphal fascicles up to 100 µm high and composed of tangled or contorted hyphae which are cylindrical, rounded at the apices, hyaline, thin-walled, clamped and 3–5 µm in diameter. (Fig. 7)

*Habitat:* Gregarious in moss.

*Material examined:* VICTORIA. Warrandyte State Park, 21.v.1996, B.A.Fuhrer 2043 (MEL 2063195).

*Remarks:* The dried material exhibits a 'varnished appearance' on both pileus and stipe surface which is indicative of an ixocutis. Microscopic examination did not show the presence of a gluten layer but did show some gelatinisation of surface hyphae on both pileus and stipe; however, there were very few adherent spores on the stipe which is contrary to the case if an ixocutis were developed. If an ixocutis is present in juvenile basidiomes, it will be very weak and the surfaces will be lubricous at most. This spectacular taxon should be easily identified as there is no other Australian species that shows the fine, yellow pruinose layer over the immature stipe with residues on the mature stipe. It appears to approach the European *Hygrocybe coccinea* (Schaeff. : Fr.) P.Kumm. but that species has a convex pileus and does not have caulocystidia on the stipe.

### Acknowledgements

The author wishes to thank Mr Bruce Fuhrer of Ringwood, Melbourne for his considerable generosity in not only allowing access to his Jumping Creek collections but also in providing superb field photographs of the material. His help and willing assistance during the examination of these collections, both with additional field notes and descriptions of the park flora, is also very gratefully acknowledged. This investigation was completed



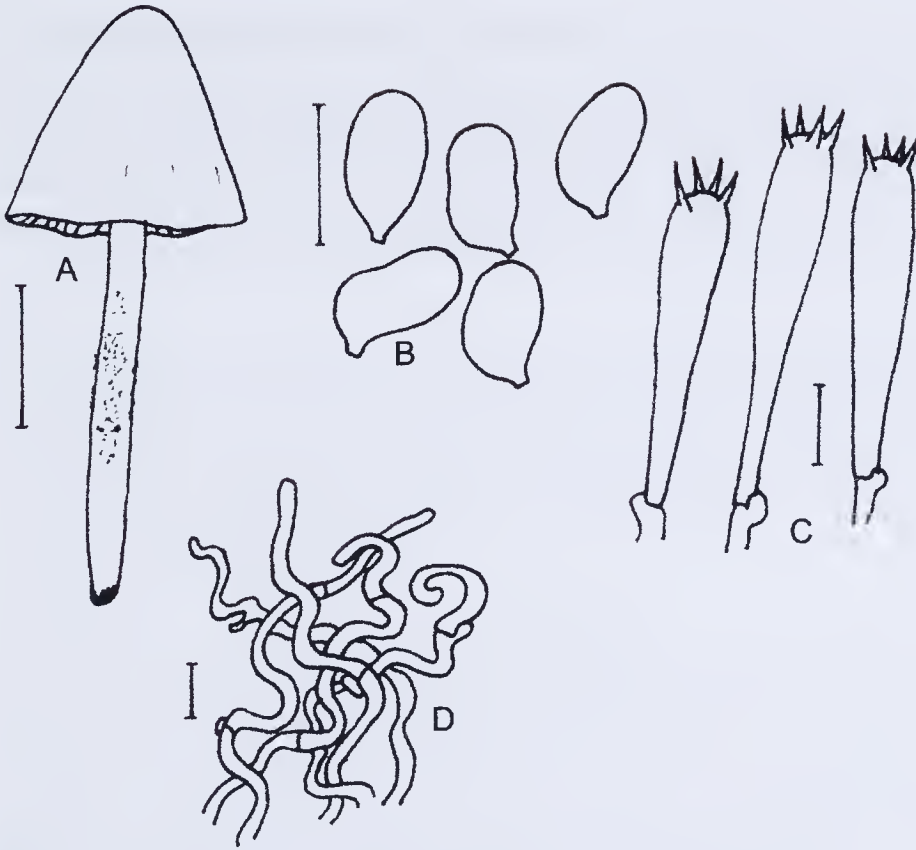


Figure 7. *Hygrocybe* sp. JCR2. A habit sketch; B spores; C basidia; D caulocystidia.

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## A Revision of *Agrostis billardierei* R. Br. (Poaceae)

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### Abstract

Observations of growth habit and habitats and statistical analysis of detailed morphological measurements on specimens of *Agrostis billardierei* R. Br. and some closely related taxa has resulted in a re-evaluation of the rank and status of some of them. New combinations are made for *Agrostis billardierei* var. *robusta* Vickery, *A. billardierei* var. *collicola* D. Morris, *A. billardierei* var. *filifolia* Vickery and *A. aemula* var. *setifolia* Vickery. The new names for these taxa are *A. robusta*, *A. collicola*, *A. punicea* var. *filifolia* and *A. punicea* var. *punicea* respectively. *Agrostis billardierei* var. *tenuiseta* D. Morris is confirmed as a good taxon.

### Introduction

As a result of recent extensive surveys and collections of *Agrostis* in Western Victoria by the senior author, the status of some published taxa was in obvious need of reassessment. In particular, the morphological and ecological relationships between *A. billardierei* var. *filifolia* Vickery and *A. aemula* var. *setifolia* Vickery appeared to be a lot closer than implied by their taxonomic status. In contrast, a number of the recognised varieties of *A. billardierei* R. Br. appeared to be more distinct than their status would indicate. For example, James and Brown (2000) found highly significant differences in both morphological assessment and DNA analysis, when comparing single populations of *A. billardierei* var. *robusta* and *A. billardierei* var. *filifolia*.

Vickery (1941) carried out the last major revision of the Australian species of *Agrostis*. Working with a limited number of specimens, she recognised three varieties of *A. billardierei*, viz. *A. billardierei* var. *billardierei*, from coastal New South Wales, Victoria, Tasmania and South Australia (20 specimens recorded), *A. billardierei* var. *filifolia*, from inland Victoria and Tasmania (2 specimens recorded) and *A. billardierei* var. *robusta* Vickery, also from inland Victoria and Tasmania (2 specimens recorded). Since 1941, many other specimens of *A. billardierei* have been collected in south-eastern Australia. Black (1943) added *A. billardierei* var. *filifolia* (2 specimens recorded) and Jessop and Toelken (1986) added *A. billardierei* var. *robusta* (2 specimens recorded) to the South Australia flora. Morris (1990) recognised additional varieties of *A. billardierei* from Tasmania, viz. *A. billardierei* var. *collicola* D. Morris (2 specimens recorded) and *A. billardierei* var. *tenuiseta* D. Morris (5 specimens recorded).

*Agrostis billardierei* var. *robusta* was separated from var. *billardierei* on the basis of its taller, rather rigid habit, non-littoral habitat, narrow, inrolled, acuminate leaves, more conspicuously scaberulous lemmas and smooth to scaberulous-sided glumes with very scabrous keels (Vickery 1941). *Agrostis billardierei* var. *filifolia* was separated from the typical variety on the basis of its more slender and rather taller habit, non-littoral habitat, very narrow, almost filiform leaves, rather few-flowered and more capillary panicles, long anthers and smooth-sided glumes (Vickery 1941). *Agrostis billardierei* var. *collicola* and var. *tenuiseta* were separated from var. *billardierei* on the basis of their slender, straight, sub-terminal awns (or awns sometimes absent in the case of the latter) and from each other on the basis of their differing habitat and stature (the former growing in non-littoral highlands and being smaller with few spikelets) (Morris 1990).

Vickery (1941) also described *Agrostis aemula* var. *setifolia* based on 3 specimens from Tasmania. Walsh and Entwisle (1994) recorded this taxon for Victoria. *Agrostis aemula* var. *setifolia* was separated from var. *aemula* on the basis of its very narrow, setaceous or sub-filiform leaves, more lax panicle, longer lemmas, awn insertion much below the middle, and long anthers (Vickery 1941). Vickery also noted: "It shows a very close superficial resemblance to *A. billardiarei* var. *filifolia*, but differs in the very pubescent lemma."

Taxonomic keys appearing in current Floras (e.g. Jessop & Toelken 1986, Simon 1993, Walsh & Entwisle 1994, Curtis & Morris 1994) largely follow Vickery's key (Vickery 1941).

Using morphological characterisation, this paper presents a statistical assessment of the relationships between these taxa and an enhanced description of each taxon. In addition, geographic distribution and environmental niches are noted.

## Methods

### MORPHOLOGY

Field collections of *Agrostis* specimens were made throughout southern Victoria over the growing seasons of 1993/94 to 1998/99 and measurement of a range of morphological characters were made (Appendix 1) for each specimen. The majority of the collection sites were located in south-west Victoria but some specimens were collected from Gippsland (eastern Victoria). Additional collections were made of *A. billardiarei* var. *tenuiseta* from the east coast of Tasmania, where it is endemic. As *A. billardiarei* var. *collicola* is confined to a few Tasmanian highland localities (Morris 1990) and fresh field collections were not readily available, measurements were made on the few extant herbarium collections.

Total height was measured from the base of the above ground plant parts to the highest part of the plant (almost always, the inflorescence) while basal tussock height was a more subjective measure of the height of the major leafy part of the tussock. Culm height was taken from the plant base to the base of the highest flag leaf. Basal leaf width measurements were of the widest non-senescent leaf and flag leaf and inflorescence measurements related to the largest inflorescence in each specimen. The width of conduplicate or involute leaves was measured without flattening these leaves out (in accord with published descriptions and keys). Leaf roll was assessed for the majority of green leaves. Inrolling, or conversely, flattening sometimes occurred where leaves had senesced, but these were not used for leaf width measurements. Where an inflorescence was not exerted from the leaf sheath, the length of the visible peduncle was recorded as zero. The height of the inflorescence was taken from the base of the flag leaf or from the lowest panicle whorl if exerted. Spikelet measurements were made under a binocular microscope (20× mag.) on one 'typical' spikelet selected from each specimen. Occasionally, where an anther was found to be missing, an anther from another spikelet of similar age and size on the same specimen was measured. Pedicel and spikelet colour was assessed as the degree of purpling (assumed to result from the accumulation of anthocyanin).

The lemma and palea of some specimens have apical nerve extensions or 'teeth' of considerable length (up to 1.5 mm and 1.2 mm respectively). All such projections are termed 'setae' here.

Specimens were also classed according to plant age. This criterion was assessed on the maturity of the measured inflorescence, and divided the specimens into 'immature' (only partly exerted and non-spreading with non-senescent spikelets), 'maturing' (becoming exerted and/or spread with non-senescent spikelets), 'mature' (fully spread with terminal spikelets senescent) and 'ripe' (most of panicle senescent).

*Agrostis billardiarei* and *A. aemula* and their varieties, were determined with the use of Vickery's taxonomic key (Vickery 1941) and Morris' descriptions (Morris 1990). Only the published key characters and not the full set of measured characters were used for



determination. Vickery's key character for growth habit was poorly specified (i.e. 'tall and robust' for *A. billardierei* var. *robusta* and 'slender' for *A. billardierei* var. *filifolia*) and was consequently excluded from consideration. The key character of habitat (i.e. littoral or non-littoral) was also excluded. On examination of the data set, it was found that the key maximum limit for spikelet length of *A. aemula* was often exceeded and so only the key minimum limit was used for determination. Where specimens did not meet all accepted key criteria for a particular taxa, they were listed as indeterminate.

## STATISTICAL TREATMENT

A total of 243 specimens were subjected to statistical analysis. Morphological data for analysis were either quantitative (continuous variable) or qualitative (discrete variable). Thirty six characters were assessed (including 12 discrete variables) and a further 14 characters were derived as ratios (e.g. inflorescence height:width), percentages (e.g. basal tussock height as a percent of total plant height) or sums (e.g. lemma body + lemma setae = total lemma length) from these. Qualitative data were transformed to an ordinal scale and treated as quantitative for some analyses. Ordinal scales varied from 3 to 5 levels, with an average of 3.8 (Appendix 1).

A selected set of 33 characters was used for multivariate analysis, including 10 of the qualitative characters (Appendix 1). None of the derived characters were used. As multivariate analysis cannot easily handle missing data, characters with missing data (number of visible branches in lowest inflorescence whorl, pedicel colour and spikelet colour) were also excluded.

All statistics were performed using the GENSTAT 5 package (Release 3.1, Lawes Agricultural Trust, Rothamstead Experimental Station).

A Symmetric Matrix (SYMMETRICMATRIX) of associations for the selected data set (using euclidean or cityblock variate type; the former for continuous variables and the latter for discrete variables), was established by forming a Similarity Matrix (FSIMILARITY). This matrix was then subjected to Principle Coordinates Analysis (PCO) to assess natural groupings of the specimens and to check the validity of the current flora key determinations. Separate PCO analysis was carried out on i) the above data set without exclusions and ii) the same data set but excluding 'immature' and 'ripe' specimens.

Discriminant (DISCRIMINANT) analysis was undertaken on the selected data sets to estimate mis-determination rates for specimens and to assign indeterminate specimens to groups. Separate discriminant analysis was carried out on: i) the selected data set without exclusions; ii) the selected data set but excluding lemma surface characters (i.e. B, Rc, Rd); and iii) the selected data set but excluding the varieties of *A. aemula*. Correlation matrices of variates and discriminant scores enabled the identification of those variates (i.e. characters) that were most influential in separating groups (i.e. taxa).

A Reduced Similarity Matrix (REDUCE) was constructed on the total (determined and reassigned) specimen data set of selected characters, using the mean similarity between groups. Hierarchical Cluster Analysis (HCLUSTER) (using the furthest neighbour criterion) of the Reduced Similarity Matrix, provided an association of the taxa for the purpose of assessing specific and varietal status. Furthest neighbour linkage was used to maximise space-dilation and minimise overlap between groups.

Ranges, means and significant differences for all measured characters (Appendix 1) were assessed by using Analysis of Variance (ANOVA) and provided for: i) identification of diagnostic characters to separate particular taxa; and ii) an enhanced description of each taxon. Least significant differences (LSD) at the 5%, 1% and 0.1% level were used to test differences in means between any two taxa.

Additional ANOVA was performed for each separate taxon to test the effect of plant age on the measured characters. Although it is recognised that this analysis was of age classes that contained specimens from varying and often different populations, it can still provide some useful overall information for each taxon.

## EXAMINATION OF HERBARIUM SPECIMENS

Approximately 280 herbarium specimens (including type specimens and 33 duplicates) from MEL, AD, HO, NSW, CANB, K, BM, WELT and CHR were examined to check conformity of: a) survey specimens to type specimens and b) other herbarium specimens to survey specimens. Measurements were not routinely undertaken on these specimens, but only for some characters where individuals required re-appraisal or confirmation of the determination. These data were not included in the statistical analysis.

## HABITAT MEASUREMENTS

Observations were made of the habitats occupied by each taxon for the field collected specimens. Composite soil samples (0-10 cm depth) were taken from a selection of sites and analysed for moisture content, pH (1:5 soil:water) and electrical conductivity (1:5 soil:water). Sites were selected to include *Agrostis* populations with substantial plant numbers and to cover a wide geographic range in south-west Victoria. Fifteen plants at each of two populations of *A. billardierei* var. *robusta* and two populations of var. *filifolia* were tagged for observation of growth habit, flowering and longevity over the 1998/99 and 1999/00 growing seasons. In addition, the position of four tussocks of var. *billardierei* at each of two sites were noted in December 1997 or 1998 and observed again two years later. Flowering time during the 1998/99 season for this taxon was noted for a further four sites.

## Results

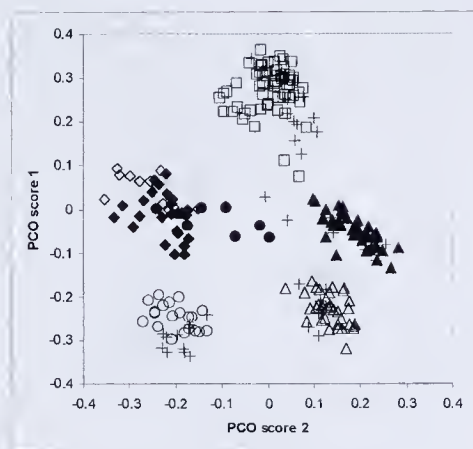
### TAXA DETERMINATION

Thirty eight specimens were classed as indeterminate on the basis of their failure to conform completely to Vickery's key (Vickery 1941). In the majority of cases, non-conformity was in only one character of the several provided by the key.

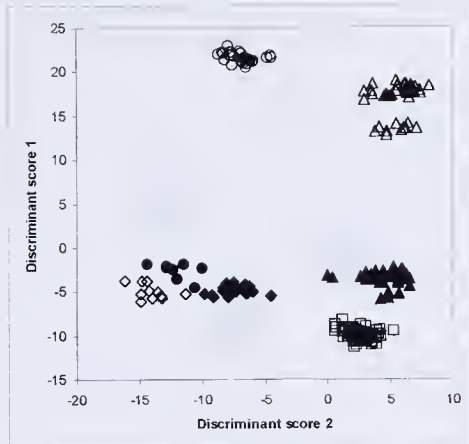
PCO analysis of the total data set, provided a clear separation of all taxa, except for *A. billardierei* var. *tenuiseta* and *A. billardierei* var. *collicola* which grouped with *A. billardierei* var. *billardierei* (Fig. 1). The first and second vectors of the coordination accounted for 41.0% of the variation detected, with the third, fourth and fifth vectors accounting for a further 22.5%. Restriction of PCO analysis to 'maturing' and 'mature' aged specimens (i.e. exclusion of 'immature' and 'ripe' panicles) made little difference to the outcome.

For the 205 determined specimens used in this study, mis-classification rate, as calculated through the discriminant analysis of data without exclusions, was zero and all taxa displayed clear separation (Fig. 2), including var. *collicola* from the type of *A. billardierei* by the first and third vectors (the latter not shown) and var. *tenuiseta* from the type by the second and third vectors. The majority of reassigned (previously indeterminate) specimens fitted well to the taxa assigned by the analysis.

Specimens conforming to *A. billardierei* (Vickery 1941, Morris 1990) numbered 152, with a further 20 indeterminate specimens being reassigned to var. *robusta* (12 specimens) or var. *filifolia* (8 specimens). Indetermination for var. *robusta* was caused by a less scabrid glume keel than expected or an excessive anther length, while in var. *filifolia*, insufficient anther length was the main criterion. In total, specimens of *A. billardierei* were determined as: 26 of var. *billardierei* (from 14 near-coastal and 2 inland sites); 75 of var. *robusta* (from 39 inland and 8 near-coastal sites); 52 of var. *filifolia* (from 17 inland sites); 11 of var. *tenuiseta* (from 4 coastal sites); and 8 of var. *collicola* (made up of 2, 2 and 4 specimens each from three separate herbarium collections from highland sites). Two reassigned specimens of var. *filifolia* from Meerlieu in central Gippsland were slightly separated from the rest of the taxon due to their smaller than average spikelets. This population was the only collection from Gippsland and may indicate a local form.



**Figure 1.** PCO score 1 and 2 for the set of selected morphological characters: ○ *Agrostis aemula* var. *aemula*. △ *A. aemula* var. *setifolia*. ◆ *A. billardieri* var. *billardieri*. ◇ *A. billardieri* var. *tenuisetata*. □ *A. billardieri* var. *robusta*. ▲ *A. billardieri* var. *filifolia*. ● *A. billardieri* var. *collicola*, + indeterminate.



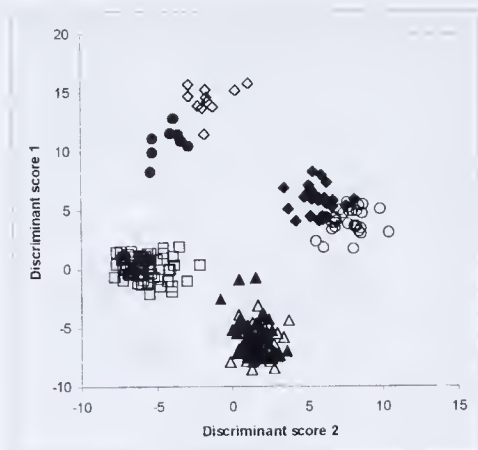
**Figure 2.** Discriminant scores 1 and 2 with indeterminates reassigned, for the set of selected morphological characters: ○ *Agrostis aemula* var. *aemula*. △ *A. aemula* var. *setifolia*. ◆ *A. billardieri* var. *billardieri*. ◇ *A. billardieri* var. *tenuisetata*. □ *A. billardieri* var. *robusta*. ▲ *A. billardieri* var. *filifolia*. ● *A. billardieri* var. *collicola*.

There were 53 specimens conforming to *A. aemula* (Vickery 1941). As *A. aemula* var. *aemula* appears to form intergrades with *A. avenacea* Gmel. (as noted by several authors e.g. Vickery 1941, Walsh & Entwistle 1994), only specimens with clear characteristics for *A. aemula* var. *aemula* (e.g. broad leaves and large spikelets) were used in this study to provide a comparison with *A. aemula* var. *setifolia*. A further 18 indeterminate specimens were reassigned to var. *aemula* (11 specimens) and var. *setifolia* (7 specimens). Indetermination was caused by excessive lemma length for var. *aemula*, and insufficient lemma length and anther length for var. *setifolia*. After reassignment, a total of 31 specimens of *A. aemula* var. *aemula* (from 16 inland sites) and 40 specimens of var. *setifolia* (from 17 inland and 1 near-coastal sites) were identified. Discriminant analysis separated var. *setifolia* into two, near but distinct, populations. On closer examination this was found to be due to the level of hairiness of the lemma back (i.e. level 3 or 4; see Appendix 1 for descriptions). There was no differentiation in the geographic range of these specimens.

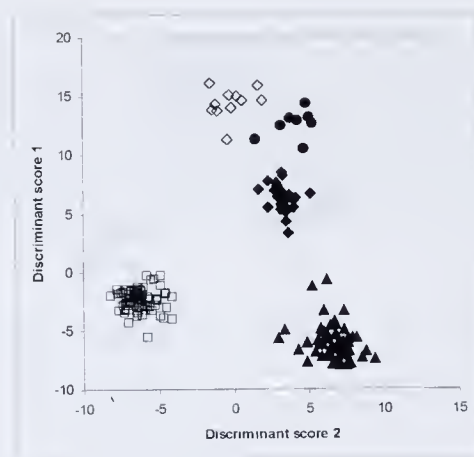
The first and second vectors of the discriminant analysis accounted for 81.2% of the variation. The first vector was highly correlated with the characters for lemma surface (B, Rc, Rd at 0.97, -0.80 and -0.76 respectively) and therefore provided considerable separation of the current varieties of *A. aemula* and *A. billardieri*. Other characters with high correlation to the first vector were glume and awn length (Glb, Gub, Ab and Ac at 0.73, 0.67, 0.68 and 0.58 respectively), lemma setae length (Ls at 0.57) and glume margin ciliation (M at -0.55). The second vector was associated with leaf width and leaf roll (Llw, Lfw and Lr at -0.83, -0.74 and 0.80 respectively), awn attachment (Aa at -0.81), palea setae and body length (Ps and Pb at 0.72 and 0.54 respectively), density of lemma back scabridity (Rd at 0.58) and awn column length (Ac at 0.50).

Discriminant analysis of the data after exclusion of lemma surface characters (i.e. hairiness or scabridity; B, Rc and Rd) brought *A. aemula* var. *setifolia* and *A. billardieri* var. *filifolia* together into the same grouping (indicating that only lemma surface charac-





**Figure 3.** Discriminant scores 1 and 2 with indeterminates reassigned, for the set of selected morphological characters with B, Rc and Rd excluded: ○ *Agrostis aemula* var. *aemula*, △ *A. aemula* var. *setifolia*, ◆ *A. billardierei* var. *billardierei*, ◇ *A. billardierei* var. *tenuiseta*, □ *A. billardierei* var. *robusta*, ▲ *A. billardierei* var. *filifolia*, ● *A. billardierei* var. *collicola*



**Figure 4.** Discriminant scores 1 and 2 with indeterminates reassigned, for the set of selected morphological characters with the varieties of *Agrostis aemula* excluded: ◆ *A. billardierei* var. *billardierei*, ◇ *A. billardierei* var. *tenuiseta*, □ *A. billardierei* var. *robusta*, ▲ *A. billardierei* var. *filifolia*, ● *A. billardierei* var. *collicola*

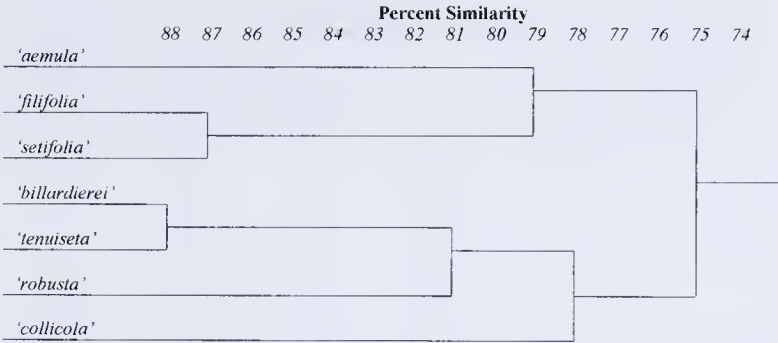
ter differentiates them) and resulted in a slight overlap of *A. aemula* var. *aemula* and *A. billardierei* var. *billardierei* in the first and second vectors (Fig. 3). Miscalculation rate was 4.4%, resulting from reassignment of four *A. billardierei* var. *filifolia* specimens to *A. aemula* var. *setifolia* and reassignment of five specimens from the latter to the former. There was no reassignment from *A. aemula* var. *aemula* to *A. billardierei* var. *billardierei*. The first and second vectors accounted for 85.4% of the variation. Separation by the first vector was largely influenced by awn attachment and length, palea setae length, leaf roll and width and anther length. The second vector was influenced by leaf roll, glume length, coarseness of lemma scabrids, glume margin ciliation, panicle stiffness and awn length.

Discriminant analysis of the varieties of *A. billardierei* alone, provided clear separation of all taxa (Fig. 4). Miscalculation rate was zero and the first and second vectors accounted for 80.4% of the variation. Separation by the first vector was mainly due to awn length and attachment, leaf roll and width, density of lemma scabrids and lemma and palea setae lengths while the second vector was influenced by coarseness of lemma scabrids, glume margin ciliation, anther length and panicle stiffness.

#### TAXA ASSOCIATION

A dendrogram for the cluster analysis of the reduced similarity matrix is shown (Fig. 5). *A. aemula* var. *aemula* separates from *A. billardierei* var. *billardierei* at 75% similarity while *A. aemula* var. *setifolia*, *A. billardierei* var. *collicola* and *A. billardierei* var. *robusta* separate from their type varieties at 79%, 78% and 81% respectively. *Agrostis billardierei* var. *filifolia* is clustered with *A. aemula* var. *aemula* rather than with *A. billardierei* var. *billardierei* and has 87% similarity to *A. aemula* var. *setifolia*. *A. billardierei* var. *tenuiseta* has 88% similarity to *A. billardierei* var. *billardierei*.





**Figure 5.** Dendrogram of hierarchical cluster analysis (furthest-neighbour criteria) for a Reduced Similarity Matrix (taxa represented by varietal epithet only).

KEY CHARACTERS

The results of ANOVA analysis based on currently recognised taxa are shown in Table 2. Except for inflorescence extension (Ie), inflorescence height to width ratio (Ih:Iw) and visible peduncle length (Ipd), significant differences were found for all measured characters at  $P \leq 0.001$ .

Table 1 summarises significant differences for LSD at the 0.1%, 1% and 5% levels for a number of taxa comparisons. Although this analysis has identified numerous characters that are significantly different, most of these cannot be used as distinctive diagnostic characters for separating taxa because the range in their values overlap. However, a number of diagnostic or nearly distinct characters can be identified for each taxon.

*Agrostis aemula* and *A. billardierei*

Fifty four percent of the measured or derived characters were significantly different between *A. aemula* var. *aemula* and *A. billardierei* var. *billardierei* (forty percent being highly significant for LSD at 0.1%). Eighty five percent of these characters related to spikelet characteristics and included glume, lemma and awn size (all larger in *A. aemula*<sup>1</sup>). *Agrostis aemula* also had longer setae points to its glumes and lemmas, smoother glume margins and more uneven glume lengths (the lower being slightly longer). Tussock height was shorter for *A. aemula*, leaf width was narrower and leaf length was shorter.

Although most character measurements overlap between these species, the generally narrower leaves, larger glumes and awns and the hairy lemmas of *A. aemula* var. *aemula* serve to distinguish it from *A. billardierei* var. *billardierei*. Although the mean inflorescence height to width ratio was the same for these species, it did not exceed a value of two for *A. billardierei* but was up to five for *A. aemula*.

*Agrostis billardierei* var. *tenuiseta*

Thirty six percent of characters separated this taxon from var. *billardierei* (twenty six percent for LSD at 0.1%). It was diagnostically separate by its short awns, which had a minute or absent column and a near terminal lemma attachment.

The leaves of this taxon tended to be more loosely inrolled (and therefore narrower), the flag leaves were shorter (some had withered tips), the spikelets less gaping and the

<sup>1</sup> It is recognised that forms of *A. aemula* var. *aemula* with similar or smaller spikelets than *A. billardierei* var. *billardierei* are currently recognised within the former taxon but were not examined as part of the current study.

**Table 1.** Summary of significant differences (\*\*\*) = LSD at 0.1%, \*\* = LSD at 1%, \* = LSD at 5%) between various comparisons of currently recognised taxa (represented by varietal epithet only).

Character	<i>'billardierei'</i> to <i>'aemula'</i>	<i>'billardierei'</i> to <i>'tenuiseta'</i>	<i>'billardierei'</i> to <i>'collicola'</i>	<i>'billardierei'</i> to <i>'robusta'</i>	<i>'billardierei'</i> to <i>'filifolia'</i>	<i>'aemula'</i> to <i>'setifolia'</i>	<i>'setifolia'</i> to <i>'filifolia'</i>
Hgt, cm			***				
Llh, cm	***		***	*	***		
Llhp, %	***		*	**	***		
Ch, cm			***				
Chp, %				*			
Lr (1-5)		***	***	***	***	***	
Llw, mm	***	***	***	***	***	***	
Lfw, mm	***	***	***	***	***	***	
Lfh, cm	**	**	***		***	*	
Lig, mm			***	***	***	**	
Ie (1-4)							
lpd, cm			**	*			
Ilb (no.)			*		***	***	
Ih, cm		**	***				
Iw, cm			***				
Ih:Iw							
Ia (1-4)				***			
Ipc (1-5)				*	*		
Sa (1-3)			***		*	***	
Sc (1-5)					***		
Sg (1-4)		***	**		*		
Glt, mm	***		***	**	*	***	
Glb, mm	***		***	***		***	
Gls, mm	***		*	***		**	
Glsp, %			***	***		*	
Gut, mm	***		***	**		***	
Gub, mm	***		***	***		***	
Gus, mm			*	***		**	
K (0-3)			***				
M (0-2)	***	***		***	***		
Glt:Gut	***		**		***		
Lt, mm	***				***	*	*
Lb, mm		**			***	***	
Ls, mm	***	***			**		**
Lsp, %	***	***	*		*		*
B (0-4)	***					***	***
Rc (0-3)	***		***	***	***	***	
Rd (0-3)	***	*	***	***	**	***	***
Pt, mm	*			***	***	***	
Pb, mm	*	*	*	***	***	***	
Ps, mm				**	***	***	
Psp, %				**	***	***	
Re, mm	*				*		
At, mm	***	***	***	**	***		**
Ac, mm	***	***	***	***	***	*	**
Ab, mm	***	***	***		***	***	*
Abp, %	**	***	***	*		***	
Aa, mm	*	***	***		***	***	
Aap, %		***	***	**	***	***	
A, mm	*				***	***	

**Table 2.** Means for morphological characters of currently recognised taxa (represented by varietal epithet only); values in the same row that share the same letter are not significantly different (assessed by LSD at 0.1% level).

Character	<i>billardierei</i>	<i>tenuiseta</i>	<i>collicola</i>	<i>robusta</i>	<i>filifolia</i>	<i>setifolia</i>	<i>aemula</i>	LSD (0.1%)
Hgt, cm	49 <i>b</i>	44 <i>b</i>	14 <i>a</i>	48 <i>b</i>	44 <i>b</i>	41 <i>b</i>	45 <i>b</i>	15
Llh, cm	33 <i>e</i>	29 <i>de</i>	8 <i>a</i>	27 <i>cde</i>	19 <i>bc</i>	15 <i>ab</i>	20 <i>bcd</i>	9.6
Llhp, %	68 <i>c</i>	70 <i>c</i>	59 <i>bc</i>	55 <i>bc</i>	42 <i>ab</i>	38 <i>a</i>	45 <i>ab</i>	16
Ch, cm	24 <i>bc</i>	24 <i>bc</i>	7 <i>a</i>	28 <i>c</i>	19 <i>bc</i>	17 <i>b</i>	20 <i>bc</i>	9.5
Chp, %	48 <i>abc</i>	55 <i>bc</i>	49 <i>abc</i>	57 <i>c</i>	43 <i>a</i>	41 <i>a</i>	44 <i>ab</i>	12
Lr (1-5)	1.0 <i>a</i>	1.7 <i>bc</i>	2.1 <i>c</i>	4.8 <i>e</i>	3.9 <i>d</i>	3.9 <i>d</i>	1.2 <i>ab</i>	0.61
Llw, mm	4.8 <i>d</i>	4.0 <i>c</i>	1.6 <i>b</i>	0.6 <i>a</i>	0.5 <i>a</i>	0.5 <i>a</i>	3.3 <i>c</i>	0.75
Lfw, mm	4.1 <i>c</i>	2.6 <i>b</i>	1.1 <i>a</i>	0.7 <i>a</i>	0.4 <i>a</i>	0.3 <i>a</i>	2.6 <i>b</i>	0.82
Lfh, cm	11.1 <i>d</i>	6.6 <i>abcd</i>	3.0 <i>a</i>	9.1 <i>cd</i>	4.7 <i>abc</i>	3.8 <i>ab</i>	6.9 <i>abcd</i>	4.7
Lig, mm	7.0 <i>d</i>	6.0 <i>cd</i>	2.6 <i>a</i>	4.1 <i>abc</i>	4.9 <i>bc</i>	3.8 <i>ab</i>	5.8 <i>bcd</i>	2.1
Ie (1-4)	3.5 <i>a</i>	3.0 <i>a</i>	2.9 <i>a</i>	3.2 <i>a</i>	3.3 <i>a</i>	3.6 <i>a</i>	3.5 <i>a</i>	1.1
lpd, cm	6.3 <i>a</i>	4.1 <i>a</i>	1.1 <i>a</i>	1.9 <i>a</i>	6.7 <i>a</i>	7.2 <i>a</i>	6.5 <i>a</i>	6.4
Ilb (no.)	4.8 <i>cd</i>	5.2 <i>d</i>	3.3 <i>abc</i>	4.5 <i>bcd</i>	3.0 <i>ab</i>	2.5 <i>a</i>	5.2 <i>d</i>	1.5
lh, cm	19 <i>b</i>	15 <i>b</i>	6 <i>a</i>	18 <i>b</i>	19 <i>b</i>	17 <i>b</i>	19 <i>b</i>	5.0
lw, cm	18 <i>b</i>	13 <i>b</i>	5 <i>a</i>	18 <i>b</i>	18 <i>b</i>	17 <i>b</i>	16 <i>b</i>	8.2
lh:lw	1.11 <i>a</i>	1.13 <i>a</i>	1.73 <i>a</i>	1.30 <i>a</i>	1.72 <i>a</i>	1.36 <i>a</i>	1.36 <i>a</i>	1.9
Ia (1-4)	1.2 <i>ab</i>	1.0 <i>a</i>	2.0 <i>b</i>	3.1 <i>c</i>	1.5 <i>ab</i>	1.5 <i>ab</i>	1.7 <i>ab</i>	0.88
Ipc (1-5)	3.8 <i>ab</i>	3.0 <i>a</i>	4.4 <i>ab</i>	2.7 <i>a</i>	5.0 <i>b</i>	4.9 <i>b</i>	4.2 <i>ab</i>	1.8
Sa (1-3)	1.6 <i>ab</i>	1.6 <i>ab</i>	2.9 <i>c</i>	1.5 <i>a</i>	2.2 <i>bc</i>	2.6 <i>c</i>	1.3 <i>a</i>	0.81
Sc (1-5)	2.7 <i>a</i>	2.1 <i>a</i>	3.9 <i>ab</i>	2.4 <i>a</i>	4.9 <i>b</i>	4.1 <i>ab</i>	3.8 <i>ab</i>	2.0
Sg (1-4)	2.7 <i>bc</i>	1.6 <i>a</i>	3.6 <i>c</i>	3.0 <i>bc</i>	3.3 <i>bc</i>	3.1 <i>bc</i>	2.5 <i>ab</i>	0.97
Glt, mm	5.1 <i>bc</i>	5.2 <i>bc</i>	3.6 <i>a</i>	4.5 <i>b</i>	5.6 <i>cd</i>	6.0 <i>d</i>	7.1 <i>e</i>	0.75
Glb, mm	5.1 <i>c</i>	5.2 <i>cd</i>	3.4 <i>a</i>	4.2 <i>b</i>	5.5 <i>cd</i>	5.9 <i>d</i>	6.9 <i>e</i>	0.73
Gls, mm	0.07 <i>ab</i>	0.00 <i>a</i>	0.20 <i>b</i>	0.33 <i>d</i>	0.11 <i>abc</i>	0.11 <i>abc</i>	0.28 <i>cd</i>	0.18
Glsp, %	1 <i>ab</i>	0 <i>a</i>	6 <i>cd</i>	7 <i>d</i>	2 <i>ab</i>	2 <i>ab</i>	4 <i>bc</i>	3.3
Gut, mm	4.8 <i>bc</i>	4.8 <i>bc</i>	3.5 <i>a</i>	4.3 <i>b</i>	4.9 <i>bc</i>	5.2 <i>c</i>	6.1 <i>d</i>	0.66
Gub, mm	4.7 <i>b</i>	4.8 <i>b</i>	3.4 <i>a</i>	4.0 <i>a</i>	4.8 <i>b</i>	5.1 <i>b</i>	5.9 <i>c</i>	0.66
Gus, mm	0.07 <i>ab</i>	0.04 <i>a</i>	0.16 <i>ab</i>	0.28 <i>c</i>	0.08 <i>ab</i>	0.09 <i>ab</i>	0.21 <i>b</i>	0.15
K (0-3)	1.9 <i>b</i>	2.2 <i>b</i>	2.8 <i>a</i>	1.9 <i>b</i>	1.7 <i>b</i>	1.9 <i>b</i>	1.9 <i>b</i>	0.69
M (0-2)	0.9 <i>b</i>	1.5 <i>c</i>	0.6 <i>ab</i>	1.6 <i>c</i>	0.1 <i>a</i>	0.3 <i>ab</i>	0.1 <i>a</i>	0.64
Glt:Gut	1.07 <i>ab</i>	1.08 <i>abc</i>	1.00 <i>a</i>	1.06 <i>a</i>	1.14 <i>cd</i>	1.15 <i>cd</i>	1.17 <i>d</i>	0.069
Lt, mm	3.2 <i>a</i>	3.2 <i>a</i>	2.8 <i>a</i>	3.5 <i>ab</i>	4.0 <i>bc</i>	4.4 <i>c</i>	3.9 <i>bc</i>	0.64
Lb, mm	2.7 <i>a</i>	3.1 <i>abc</i>	2.7 <i>a</i>	2.9 <i>ab</i>	3.2 <i>bc</i>	3.4 <i>c</i>	2.9 <i>ab</i>	0.45
Ls, mm	0.50 <i>bc</i>	0.08 <i>a</i>	0.32 <i>ab</i>	0.59 <i>bc</i>	0.76 <i>cd</i>	1.01 <i>d</i>	1.04 <i>d</i>	0.31
Lsp, %	15 <i>bc</i>	3 <i>a</i>	11 <i>b</i>	17 <i>cd</i>	19 <i>cd</i>	23 <i>de</i>	26 <i>e</i>	6.0
B (0-4)	0.0 <i>a</i>	0.0 <i>a</i>	0.0 <i>a</i>	0.0 <i>a</i>	0.0 <i>a</i>	3.8 <i>b</i>	4.0 <i>c</i>	0.22
Rc (0-3)	2.0 <i>d</i>	1.9 <i>d</i>	0.4 <i>b</i>	3.0 <i>e</i>	1.1 <i>c</i>	1.0 <i>c</i>	0.0 <i>a</i>	0.26
Rd (0-3)	1.4 <i>b</i>	1.1 <i>b</i>	0.3 <i>a</i>	2.7 <i>c</i>	3.0 <i>c</i>	1.0 <i>b</i>	0.0 <i>a</i>	0.49
Pt, mm	2.2 <i>a</i>	2.4 <i>ab</i>	2.5 <i>ab</i>	2.7 <i>b</i>	3.4 <i>c</i>	3.5 <i>c</i>	2.5 <i>ab</i>	0.43
Pb, mm	2.1 <i>a</i>	2.4 <i>ab</i>	2.4 <i>ab</i>	2.5 <i>bc</i>	2.8 <i>cd</i>	3.0 <i>d</i>	2.4 <i>ab</i>	0.39
Ps, mm	0.07 <i>ab</i>	0.02 <i>a</i>	0.02 <i>a</i>	0.19 <i>b</i>	0.57 <i>c</i>	0.57 <i>c</i>	0.08 <i>ab</i>	0.15
Psp, %	3 <i>ab</i>	1 <i>a</i>	1 <i>a</i>	7 <i>b</i>	17 <i>c</i>	16 <i>c</i>	3 <i>ab</i>	4.3
Re, mm	2.3 <i>ab</i>	2.6 <i>bc</i>	2.1 <i>a</i>	2.3 <i>abc</i>	2.6 <i>bc</i>	2.8 <i>c</i>	2.6 <i>bc</i>	0.45
At, mm	7.0 <i>c</i>	0.7 <i>a</i>	2.3 <i>b</i>	5.8 <i>c</i>	8.9 <i>d</i>	10.0 <i>de</i>	10.7 <i>e</i>	1.3
Ac, mm	2.7 <i>c</i>	0.0 <i>a</i>	0.0 <i>a</i>	2.1 <i>b</i>	3.5 <i>d</i>	3.9 <i>d</i>	3.6 <i>d</i>	0.52
Ab, mm	4.3 <i>c</i>	0.7 <i>a</i>	2.3 <i>b</i>	3.8 <i>c</i>	5.4 <i>d</i>	6.0 <i>d</i>	7.1 <i>e</i>	1.0
Abp, %	62 <i>ab</i>	100 <i>c</i>	100 <i>c</i>	65 <i>ab</i>	60 <i>a</i>	60 <i>a</i>	66 <i>b</i>	4.7
Aa, mm	1.2 <i>b</i>	2.8 <i>c</i>	2.6 <i>c</i>	1.2 <i>b</i>	0.6 <i>a</i>	0.6 <i>a</i>	1.4 <i>b</i>	0.27
Aap, %	39 <i>b</i>	88 <i>c</i>	89 <i>c</i>	33 <i>b</i>	15 <i>a</i>	14 <i>a</i>	36 <i>b</i>	6.0
A, mm	0.74 <i>ab</i>	0.66 <i>a</i>	0.68 <i>a</i>	0.62 <i>a</i>	1.28 <i>c</i>	1.28 <i>c</i>	0.92 <i>b</i>	0.24

inflorescences shorter (many larger inflorescences had disarticulated at the time of collection). These differences are likely to be due to most of the examined specimens being mature to very mature (see discussion for Age Effects). The outer glumes had more ciliated margins than for var. *billardierei* and while lemma setae were shorter, lemma bodies were longer on average.

*Agrostis billardierei* var. *collicola*

Sixty eight percent of characters were significantly different between this taxon and var. *billardierei* (with fifty percent for LSD at 0.1%). Except for the culm height to total height percent (Chp), all the vegetative characters were significantly smaller; total plant, tussock and culm heights and leaf widths being diagnostically distinct. Inflorescences and spikelets were also significantly smaller than var. *billardierei*, although the largest examples of var. *collicola* did exceed the smallest examples of the type variety. Despite the smaller spikelets, the lemmas (and paleas) of var. *collicola* displayed a similar size range to var. *billardierei*; mean lower glume:lemma length (including setae) being 1.20 for the former and 1.62 for the latter.

Apart from the diagnostically distinct, short awns and near terminal awn attachment, var. *collicola* generally possessed glumes with dense, finely scabrid surfaces (extending from keels to near margins) and lemmas with almost completely smooth surfaces. The glumes of var. *billardierei* and var. *tenuiseta* (apart from the keels) were generally smooth or with occasional scattered scabrid projections and the lemmas normally had at least some microscopic scabrid projections near the central nerve.

The awns of var. *collicola* were significantly longer than for var. *tenuiseta* and tend to be decurrent from the lemma back, rather than having a column (even a minute one, as is often the case in var. *tenuiseta*).

*Agrostis billardierei* var. *robusta*

Fifty six percent of characters were significantly different between this taxa and var. *billardierei* (thirty four percent being for LSD at 0.1%). As well as the diagnostic characters of narrower and inrolled leaves and distally densely coarse scaberulous lemmas, var. *robusta* was significantly different from var. *billardierei* in its shorter ligules, less stiff inflorescences, shorter glumes and awns, longer paleas, longer glume and palea setae and glumes with greater ciliation of margins. However, the currently used diagnostic character of more scabrous keels of the outer glumes was not distinct between the two taxa. Contrary to previous descriptions (Vickery 1941, Walsh & Entwistle 1994) there was little evidence of scabrid projections on the sides of the glumes, except very occasionally and then distally scattered. Examination of the holotype agreed with this finding. There were no obvious character differences between the coastal and inland specimens for either taxon.

Besides the generally distinct scabridity of the distal surfaces of the lemmas and the narrow leaf width and inrolling of var. *robusta*, a few other characters could be useful in identifying this taxon. For example, ligule length could be a guide. Sixty nine percent of var. *billardierei* had ligules greater than 5 mm (with 53% greater than 6 mm) compared to only 13% of var. *robusta* (with none greater than 6 mm). Another useful character is the length of the outer glume setae expressed as a percent of the total glume length (Glsp). Seventy three percent of var. *robusta* had Glsp greater than 5% compared to none for var. *billardierei*.

*Agrostis billardierei* var. *filifolia*

This taxon was separated from var. *billardierei* in sixty four percent of measured characters (forty eight percent being for LSD at 0.1%). The main diagnostic character which separated var. *filifolia* from var. *billardierei* and var. *robusta* was its near-basal awn attachment (8 to 23% of lemma length with a mean of 15%) compared to mid-back attachment (29 to 47% with a mean of 39% for var. *billardierei* and 23 to 45% with a



mean of 33% for var. *robusta*). The taxon was also clearly separated from var. *billardierei* by its narrow leaves and longer palea setae (0.3 to 1.2 mm compared to 0.0 to 0.2 mm). Although the ranges in palea setae length overlapped between var. *filifolia* and var. *robusta*, only 4% of var. *robusta* specimens exceeded 0.3 mm compared to 88% of var. *filifolia* specimens. The lemma surface often served to distinguish these three taxa. While the lemma of var. *filifolia* was uniformly minutely granular-papillose to scaberulous, the lemma of var. *billardierei* was sparsely and minutely granular to scaberulous on the keel and distal part of the lemma, and var. *robusta* was generally strongly and densely scaberulous in the distal part of the lemma extending down the keel (although this character was occasionally found to be less obvious in very mature or stunted specimens). In both vars. *billardierei* and *robusta*, the lemma was almost completely devoid of scabrosities on the proximal lateral surfaces.

Other significantly different but non-diagnostic characters separating var. *filifolia* from var. *billardierei* were its shorter basal tussock, shorter flag leaves, shorter ligules, less branched inflorescence, more purple spikelets, larger lemmas, paleas, awns and anthers and less ciliated glume margins.

In addition to its diagnostically distinct characters, var. *filifolia* differed significantly from var. *robusta* in having shorter culms, shorter flag leaves, less branched, stiffer, less crowded and more purple inflorescences and larger glumes, lemmas, paleas, awns and anthers. Setae points on glumes, lemmas and paleas were longer but glume margins were less ciliated. Although both taxa had narrow leaves, var. *filifolia* leaves were either flat, conduplicate or pseudo-convolute, in contrast to the strongly involute to convolute leaves of var. *robusta*.

#### *Agrostis aemula* var. *setifolia*

This taxon was diagnostically separable from var. *aemula* in its longer palea setae (0.3 to 0.9 mm compared to 0.0 to 0.3 mm) and lower awn attachment (8 to 26% compared to 25 to 46%). It was also distinct, on the basis of leaf width (0.2 to 1.0 mm compared to 2.0 to 4.5 mm). The taxon also differed from *A. aemula* var. *aemula* in its significantly shorter ligules (Lig), lesser branched panicles, less clustered spikelets, shorter glumes<sup>2</sup>, glume setae and awn bristles and longer lemmas, paleas and anthers. The lemmas were also slightly less hairy on average.

Apart from its hairy lemmas, *A. aemula* var. *setifolia* differed statistically from *A. billardierei* var. *filifolia* only in a few floret characters, including slightly longer lemma setae and awns.

#### AGE EFFECTS

Table 3 summarises the results of ANOVA analysis for each taxon according to age class (see Methods for descriptions). The effects of plant age (as defined by inflorescence age) was greatest for *A. billardierei* var. *filifolia*, *A. aemula* var. *setifolia* and *A. aemula* var. *aemula*. Little or no effect was seen for *A. billardierei* var. *billardierei* or *A. billardierei* var. *tenuiseta*. Obviously the uneven numbers of specimens in each age class for some taxa inhibits detailed assessment but some trends are evident.

Significant differences resulted from analysis of overall plant height, tussock height and culm height for a number of taxa. In general, the relative heights to overall height for tussocks and/or culms decreased with age. For *A. billardierei* var. *filifolia*, *A. aemula* var. *setifolia* and *A. aemula* var. *aemula*, this was the result of increasing overall plant height with age, at least to the 'mature' age. At the 'ripe' age for these taxa and for both the 'mature' and 'ripe' ages of *A. billardierei* var. *robusta*, overall height was less on average than for

<sup>2</sup> It is recognised that smaller spikelet forms of *A. aemula* var. *aemula* (e.g. 3.6 to 5.5 mm, as reported by Walsh and Entwisle 1994) are likely to have glume lengths similar to or shorter than those of var. *setifolia*.

**Table 3.** Number of specimens assessed for each age class of the currently recognised taxa (represented by varietal epithet only) and measured plant characters showing significant differences (\*\*\*) =  $P \leq 0.001$ , \*\* =  $P 0.001$  to  $P 0.01$ , \* =  $P 0.01$  to  $P 0.05$ ) with age.

Taxon		<i>billardierei</i>	<i>tenuiseta</i>	<i>collicola</i>	<i>robusta</i>	<i>filifolia</i>	<i>setifolia</i>	<i>aemula</i>
Age	I	1	0	2	4	9	4	5
	G	4	2	2	17	16	19	6
	M	12	3	4	28	17	5	5
	R	9	6	0	14	2	5	4
Vegetative Character	Hgt			*		**	*	**
	Llhp			*			*	*
	Chp				*	**		***
	Lr		**					
Inflorescence Character	Iw				**	***	***	**
	Ia				*	***		
	lpc			**			**	***
	Sa					**		
Spikelet Character	Sg				*		***	**
	Glt					**		
	Ls					**		
	Ps					**		*
	At					*	*	
	Aa							*

I = immature, G = maturing, M = mature, R = ripe

younger aged plants and either reflects an earlier maturing of smaller and less robust plants or the disarticulation of early and taller inflorescences than those still present and able to be assessed by the study. Although relative tussock height was also significantly different for *A. billardierei* var. *collicola* (between taller immature plants and smaller maturing plants), the results are based on too few specimens to have any validation.

Leaf roll increased with age for *A. billardierei* var. *tenuiseta* but only to a value of 2 (i.e. some leaves displayed slight inrolling). Other characters, thought to be associated with age, such as flag leaf length, inflorescence height and spikelet gape were not significantly different, but this result may just reflect the small numbers of specimens assessed by ANOVA and the lack of any immature specimens.

Panicles of *A. billardierei* var. *robusta* and *A. billardierei* var. *filifolia* showed significant stiffening with age and, along with the varieties of *A. aemula*, broadened with age, as expected. Increasing age significantly increased the purpling of the panicles and/or spikelets of *A. billardierei* var. *collicola*, *A. aemula* var. *setifolia* and *A. aemula* var. *aemula*.

The generally gaping glumes of 'immature' spikelets of *A. billardierei* var. *robusta* and the two *A. aemula* varieties progressively closed with age. The same trend was noted for *A. billardierei* var. *filifolia* but was not significant.

The glumes, lemma setae, palea setae and awns of *A. billardierei* var. *filifolia* showed significantly decreased sizes as age progressed. The same trends were observed in *A. aemula* var. *setifolia* for glumes and awns but only awns were significantly different. Delicate structures such as awns and setae points are likely to show reduced length with age, due to broken or withered tips, but the reduced glume length cannot be explained by the same process (no changes to glume setae length were evident). Mean glume lengths for *A. billardierei* var. *filifolia* were 6.0, 5.7, 5.3 and 5.2 mm for 'immature', 'maturing', 'mature' and 'ripe' specimens respectively, representing a 13% reduction overall. Further

study would be required to ascertain whether this is a real reduction in size with age or an artefact of the collection process (i.e. the same plant populations were not represented in each age class).

*Agrostis aemula* var. *aemula* also shows significant differences in palea setae length, but these do not follow a trend in one direction. Awn attachment height significantly increased with age in this species, despite no change in lemma length. This again, may be an artefact of the collection process.

#### EXAMINATION OF HERBARIUM SPECIMENS

Fifty eight percent of the herbarium specimens examined had been determined as *A. billardierei* var. *billardierei*. Comparison with the type confirmed 135 of these determinations. This included six specimens from Kangaroo Is. (Cape de Couedic and Rocky River N.P.), despite their small stunted appearance (about 15 cm tall with flat leaves, 2-3.5 mm wide), very short, often enclosed panicles and generally smaller than average spikelets. Vickery, on her determination label, regarded one of these specimens as 'a form' of var. *billardierei* (Rocky River, *J B Cleland*, 24 Nov. 1945, AD 96243134).

Three specimens determined as *A. billardierei* var. *billardierei* were found to be *A. aemula* var. *aemula* while the reverse was true for a further six specimens. Superficially, these 2 taxa are similar in habit and leaf character. Even the type sheet has both taxa mounted on it (*R Br.* 6218, 1802-05, BM), a mistake referred to in the earlier revision (Vickery 1941).

An additional 25 specimens were found to be incorrectly determined as *A. billardierei* var. *billardierei*. These included five specimens of *A. avenacea* with glabrous lemma backs (but hairy sides), three of *A. venusta* Trin., one each of *A. capillaris* L. var. *aristata* (Parnell) Druce (syn. *A. castellana* Boiss. & Reut.; Batson 1998) and *A. billardierei* var. *filifolia*, three of *A. billardierei* var. *tenuiseta* and 12 of *A. billardierei* var. *robusta*. All of these taxa have lemmas with hairless backs like *A. billardierei* var. *billardierei*, and because of their comparative rarity, are likely to have been overlooked or not considered during determination. Some confusion between var. *billardierei* and var. *robusta* was evident for a number of South Australian and Tasmanian specimens. Some specimens of var. *billardierei* (often inland collections) had distally finely scaberulous lemmas, not unlike some lesser scabrid forms of var. *robusta* (e.g. specimens from the Boomer Marsh/Marion Bay/Maria Is. region of Tasmania). In these cases, other characters (e.g. leaf width) were used for diagnosis.

Most of the specimens determined as *A. billardierei* var. *robusta* (15 of 17) and *A. aemula* var. *setifolia* (18 of 19) were confirmed. Although the types for these taxa have contracted, just-emerging inflorescences and the basal leaves are partially senescent and therefore rather stiff, spikelet features serve as good diagnostic characters. Nevertheless, for each of these taxa, three specimens had been incorrectly determined as *A. aemula* var. *aemula*.

Only 12 of 23 specimens determined as *A. billardierei* var. *filifolia* conformed to the type. The remaining specimens were referable to *A. billardierei* var. *robusta* (5), *A. aff. avenacea* (2), *A. venusta* (2) or *A. aemula* var. *setifolia* (2). A number of stunted specimens from near-coastal south-east South Australia were difficult to place. They had low awn insertion points like *A. billardierei* var. *filifolia* but rather small and crowded spikelets, scabrid lemmas and inrolled leaves like var. *robusta*. Vickery regarded one of these as 'a peculiar form' of var. *filifolia* (Cape Banks, *J B Cleland*, 27 Nov. 1945, AD 97222340).

#### CONCLUSION

The results of the statistical analyses of the survey specimens and examination of herbarium specimens are evidence of a taxonomic position supporting all the currently recog-

nised taxa, but at levels and in combinations different from those currently accepted. An arrangement that is concordant with the analyses has:

- (1) *A. aemula* var. *setifolia* specifically distinct from *A. aemula* var. *aemula*
- (2) *A. billardierei* var. *filifolia* and *A. aemula* var. *setifolia* as varieties of the same species
- (3) *A. billardierei* var. *billardierei*, *A. billardierei* var. *robusta*, *A. billardierei* var. *collicola* and a taxon including *A. billardierei* var. *filifolia* and *A. aemula* var. *setifolia* recognised as separate species.

*Agrostis billardierei* var. *tenuiseta* has a number of distinct characters that separate it from *A. billardierei* var. *billardierei*, but PCO and cluster analysis suggest a varietal relationship rather than a specific one.

Although *A. aemula* var. *aemula* is superficially similar to *A. billardierei* var. *billardierei* in vegetative form, there appears to be sufficient spikelet differences (apart from hairy lemmas) to maintain their separate specific status.

The appropriate combinations and new species descriptions are made in the following section.

## Taxonomy

### KEY TO TAXA TREATED IN PRESENT STUDY

1. Leaves greater than 2 mm wide and flat.....2
1. Leaves 2 mm wide or less.....3
2. Awn greater than 3.5 mm long, inserted just below lemma mid-back, exceeding the glumes .....1a. *A. billardierei* var. *billardierei*
2. Awn less than 2.0 mm long (or absent), inserted near lemma apex, not or hardly exceeding the glumes .....1b. *A. billardierei* var. *tenuiseta*
3. Awn greater than 3.5 mm, inserted below lemma mid-back, plants 20 cm tall or greater, leaves mainly involute or conduplicate (sometimes flat) (lowlands) .....4
3. Awn less than 3.5 mm, inserted near lemma apex, plants less than 20 cm tall, leaves mainly flat (or conduplicate to slightly inrolled on drying) (highlands).....
- .....2. *A. collicola*
4. Awn inserted within lower 1/4 of lemma, palea setae mainly 0.4 mm long or more, anthers 0.8 mm long or more, leaves mainly conduplicate or flat .....5
4. Awn inserted from lower 1/4–1/2 of lemma mid-back, palea setae mainly less than 0.4 mm, anthers 1.0 mm long or less, leaves mainly involute .....3. *A. robusta*
5. Lemma covered in hairs in the lower 3/4 .....4a. *A. punicea* var. *punicea*
5. Lemma (excluding callus) without hairs .....4b. *A. punicea* var. *filifolia*

### TAXON DESCRIPTIONS

The following descriptions are an expansion of those provided by Walsh and Entwistle (1994) and Morris (1990). A selected list of examined specimens accompany each taxon description while a full list of examined specimens is available from the senior author for interested readers.

1. *Agrostis billardierei* R. Br., *Prodr.* 171 (1810). *Type*: New South Wales, Port Jackson, 1802-05, *R Brown* (holotype BM).

Mid to dark green (sometimes bluish-green), tufted, glabrous, *perennial* (may be annual under unfavourable conditions), 25–75 cm tall (including inflorescences but these sometimes overtopped by leaves); culms ascending or erect, 15–40(–50) cm long. *Leaf* blades rather stiff, scabrous, flat (sometimes folded or loosely inrolled on drying); basal leaves (often forming a flattened tussock) 15–40 cm long, (2–)3–7 mm wide; ligules obtuse, 3–12 mm long. *Inflorescence* generally a rather stiff, open panicle with erect to spread-

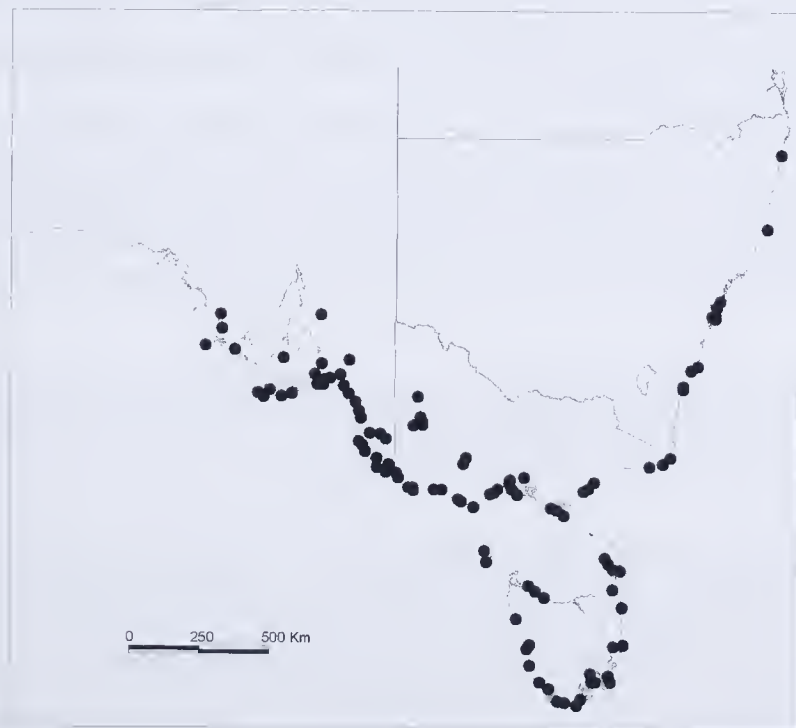


ing branches, 10–30 cm long, 5–30 cm wide, its base enclosed by the upper leaf sheath or its lower branches becoming free with maturity; peduncle 2–15 cm long if visible; 2–7 branches in the lowest whorl; spikelets generally partly overlapping. *Spikelets* (3.0–)4.0–6.5(–7.0) mm long overall (excluding awn); glumes acuminate, subequal, keeled; lemma 2.5–4.5 mm long overall, hairless except for callus tuft and more or less shining (often with scattered, very fine to microscopic scabrid projections in the upper half and near the central nerve in the lower half but sometimes distally finely scaberulous), with 2–4 setae at apex; palea 1.5–3.0 mm long overall, narrowly and very shortly bifid at the apex (points to 0.2 mm long); rachilla extension forming a plumose bristle (1.5)–2.0–3.0 mm long (including hairs); anthers 0.5–1.0 mm long. **Coast Blown-grass.**

**1a. *Agrostis billardierei* var. *billardierei***

Sometimes shortly rhizomatous. Flag *leaves* to 20(–30) cm long, 2–5(–8) mm wide. *Panicle* branches and pedicels and spikelets usually purple to dark or reddish-purple (even at inflorescence emergence) but fading to dull brown with age. Mature *spikelets* more or less gaping. Glume apex occasionally with a fine seta to 0.3 mm long, moderately scabrous along the keel and often lightly scaberulous on the sides, margins entire or with a few scattered cilia; lemma setae 0.2–1.0 mm long; awn fine, bent, (3.5–)5.0–9.0 mm long, well exceeding the glumes, attached 30–45% from the lemma base.

*Distribution:* Widely distributed along the coast in south-eastern Australia from the vicinity of Grafton in New South Wales, to at least as far west as Port Lincoln, South Australia with a few scattered inland occurrences (e.g. Little Desert in Victoria), and in Tasmania occurring virtually all around the coast (including Bass Strait islands) (Fig. 6). Also occurring through coastal areas of New Zealand except the far north (Kermadec Is) and, apparently, the south-western part of the South Island. (Fig. 6)



**Figure 6.** Distribution map of known collections of *Agrostis billardierei* var. *billardierei* in SE Australia.

*Ecology*: See general notes on habitat and phenology following taxonomic section.

*Selected specimens examined*: **SOUTH AUSTRALIA**: Port Elliot, 15 Jan. 1913 (AD); Harriet River, Kangaroo Is., 7 Oct. 1922, *Osborn* (AD); Port Lincoln, 17 Dec. 1941, *Cleland* (AD); 10 km west of Naracoorte, 18 Nov. 1961, *Hunt* (AD); Bankers Knoll, Younghusband Penin., 15 Dec. 1981, *Williams 12180* (AD, MEL); Warooka, 16 Nov. 1989, *Brown 455* (MEL, HO); near mouth of Marne River, 19 Dec. 1995, *Spooner* (AD). **NEW SOUTH WALES**: Port Macquarie, Nov. 1915, *Boorman* (NSW); Cave Beach, 4.8 km SW Jervis Bay, 12 Oct. 1971, *Coveny 3683* (NSW); North Headland, Wamberal, 10 Nov. 1973, *Jacobs 638* (NSW); Long Beach, Batemans Bay, 18 Nov. 1991, *Crawford 1413* (NSW, MEL). **VICTORIA**: Wingan Inlet N.P. west of mouth, 23 Nov. 1969, *Beaglehole and Finck 32002* (MEL, NSW); Cape Shanck, 3 Dec. 1970, *Todd 27* (MEL); Point Lonsdale, 10 Dec. 1983, *Albrecht 694* (MEL); Little Desert N.P., 18 Dec. 1983, *Carr 7704* (MEL); Walkerville North, 5 Dec. 1994, *Paget 1146* (MEL); St. Marnock's Swamp, Crossroads, south of Eurambeen, 4 Jan. 1996, *Brown 1117* (MEL). **TASMANIA**: South Port, Jan. 1850, *Smart* (MEL); Eaglehawk Neck, 15 Jan. 1949, *Blake 18281* (HO); Wybalenna Is., off Flinders Is., 12 Dec. 1968, *Harris* (HO); Rocky Cape, 7 Jan. 1977, *Mason 13249* (HO); Peron Dunes, St. Helens Point, 7 Jun. 1983, *Buchanan 1196* (HO); Turua Beach, Deadmans Bay, 21 Jan. 1987, *Moscal 14225* (HO, MEL); Planters Beach, Cockle Creek, 2 Feb. 1998, *Buchanan 15056* (HO).

**1b.** *Agrostis billardierei* var. *tenuiseta* D. Morris, *Muelleria* 7: 147 (1990). *Type*: Tasmania, Dolphin Sands, Nine Mile Beach, 10 Dec. 1984, *Buchanan 4763* (holotype HO; isotype NSW).

Often rhizomatous. Flag *leaves* to 12 cm long, (1.5–)3–4 mm wide. *Panicle* branches, pedicels and spikelets mainly green tinged with purple but fading to straw with age. Mature *spikelets* hardly gaping. Glume apex without a fine seta or to 0.1 mm long, moderately to strongly scabrous along the keel and often lightly scaberulous on the sides, margins ciliated; lemma setae to 0.2 mm long or absent; awn very fine, straight or slightly curved, 0.5–2.5 mm long (sometimes absent), not or hardly exceeding the glumes, attached 70–95 % from the lemma base.

*Distribution*: Apparently confined to coastal areas in north-eastern Tasmania (including eastern Bass Strait islands). (Fig. 7)

*Ecology*: See general notes on habitat and phenology following taxonomic section.

*Selected specimens examined*: **TASMANIA**: Clarke's Is., Furneaux Group, 26 Jan. 1966, *Whinray 1572* (CANB), Babel Is., Furneaux Group, 22 Jan. 1967, *Whinray 1764* (MEL); Whitemark, Flinders Is., Dec. 1975, *Morris* (HO); Passage Is., Furneaux Group, 6 Jan. 1979, *Whinray* (MEL); Kelvedon Beach, Great Oyster Bay, 28 Jan. 1999, *Brown 1579* (MEL); Mayfield Beach, Great Oyster Bay, 28 Jan. 1999, *Brown 1585* (MEL); Seamander Beach, Beaumaris, 15 Jan 2000, *Brown 1595* (HO).

**2.** *Agrostis collicola* (D. Morris) A.J. Brown & N.G. Walsh, *stat. nov.* *Agrostis billardierei* R. Br. var. *collicola* D. Morris, *Muelleria* 7: 147 (1990). *Type*: Tasmania, Saddle between The Hippo and Moonlight Ridge Hill 3, 10 Feb. 1985, *Collier 309* (holotype HO).

Mid to dark-green, tufted, glabrous, weak *perennial*, 10–20 cm tall (including inflorescences); culms erect, 5–10 cm long. *Leaf* blades flat to conduplicate (sometimes pseudoconvolute on drying); basal leaves (generally forming a small erect tussock or tuft) 5–15 cm long, 1–2 mm wide; flag leaves 1.5–7.5 cm long, 0.2–2.0 mm wide; ligules obtuse, 1.5–4.0 mm long. *Inflorescence* an open panicle with spreading branches, 2–9 cm long, 4–9 cm wide, its base enclosed by the upper leaf sheath or its lower branches becoming free with maturity; peduncle 1–3 cm long if visible; 2–4 branches in the lowest whorl; branches and pedicels green, becoming purple with maturity; spikelets partly overlapping to not overlapping, generally gaping. *Spikelets* 2.5–4.0 mm long overall (excluding awn);



**Figure 7.** Distribution map of known collections of *Agrostis billardierei* var. *tenuiseta* in SE Australia.



**Figure 8.** Distribution map of known collections of *Agrostis collicola* (syn. *Agrostis billardierei* var. *collicola*) in SE Australia.

usually purple (green when immature); glumes acuminate and keeled (generally the keel extending to a fine seta up to 0.5 mm long), subequal, moderately to coarsely scabrous along the keel and densely and finely scaberulous on sides, margins smooth or with a few scattered cilia; lemmas 2.5–3.5 mm long overall, hairless except for callus tuft, smooth, sometimes purple streaked, with 2–4 setae at apex 0.2–0.5 mm long; awn very fine, straight, decurrent from central nerve of lemma, 1.0–3.5 mm long, attached 80–95% from the lemma base; palea 2.0–3.0 mm long (minutely bifid at the apex if at all); rachilla extension forming a plumose bristle 1.5–2.5 mm long (including hairs); anthers 0.4–0.8 mm long. **Hill Blown-grass.**

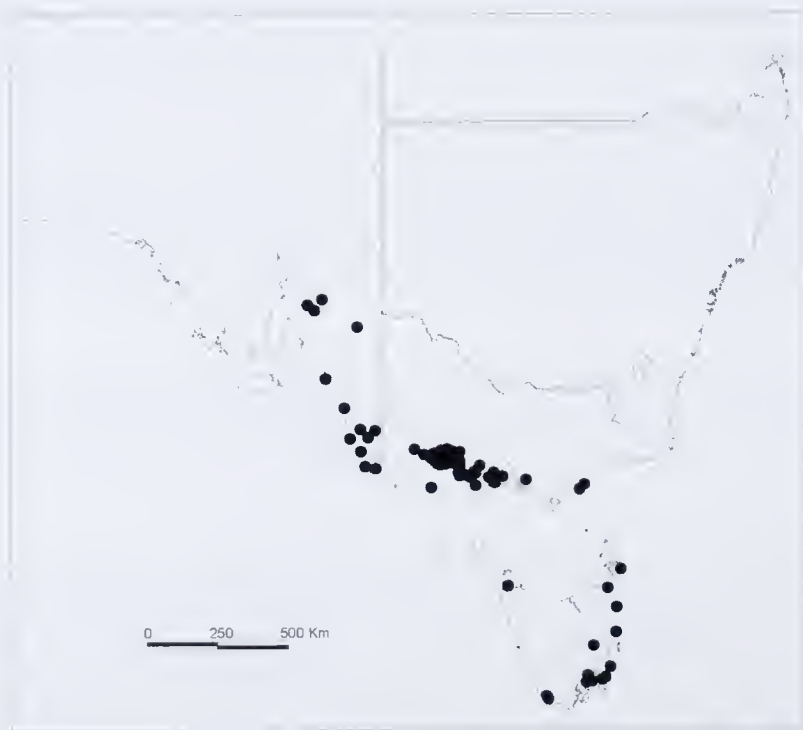
*Distribution:* Apparently confined to mountainous areas of Tasmania, from 800–850 m altitude (Fig. 8).

*Ecology:* See general notes on habitat and phenology following taxonomic section.

*Selected specimens examined:* **TASMANIA:** Lake Ewart, 7 Feb. 1987, *Buchanan 10071*, (HO); Lake Will south of Barn Bluff, 15 Jan. 1989, *Collier 3941*, (HO).

**3. *Agrostis robusta*** (Vickery) A.J. Brown & N.G. Walsh *stat. nov.* *Agrostis billardierei* R. Br. var. *robusta* Vickery, *Contr. New South Wales Natl Herb.* 1: 110 (1941). *Type:* Victoria, Melbourne, 17 Nov. 1853, *Adamson 224* (holotype K).

Mid to light-green (new shoots can be bluish-green), tufted, glabrous, *annual or perennial*, 25–75 cm tall (including inflorescences); culms ascending or erect, 10–55 cm long. *Leaf* blades rather stiff to lax, scabrous, convolute to strongly involute (sometimes flattening with age); basal leaves (sometimes forming an erect tussock) 10–50 cm long, 0.2–1.0(–1.5) mm wide; flag leaves 2.5–15(–35) cm long, 0.2–1.0(–1.5) mm wide; ligules obtuse, 2–7 mm long. *Inflorescence* an open panicle with spreading to lax branch-



**Figure 9.** Distribution map of known collections of *Agrostis robusta* (syn. *Agrostis billardierei* var. *robusta*) in SE Australia



es (except at maturity), 10–25 cm long, 10–30 cm wide, its base enclosed by the upper leaf sheath or its lower branches becoming free in late maturity; peduncle 2–9 cm long if visible; 1–8 branches in the lowest whorl; branches and pedicels generally green to greyish-green or occasionally purplish-green; spikelets generally partly overlapping and more or less gaping. *Spikelets* 3.5–5.5 mm long overall (excluding awn), usually green to greyish-green; glumes acuminate and keeled (generally the keel extending to a fine seta 0.6–0.8 mm long), subequal or the lower slightly longer, moderately scabrous along the keel but smooth on sides (very occasionally lightly and distally scaberulous), margins with a few scattered cilia to fully ciliated; lemma 2.5–4.5(–5.5) mm long overall, hairless except for callus tuft, rather firm, strongly scaberulous in the upper half or at least on and near the setae and nerves towards the more or less fluted apex, more or less shining in the lower half and devoid of scabrid projections except for near the central nerve, with 2–4 setae at apex 0.3–1.0 mm long; awn bent, (3.5–)4.5–7.0(–8.0) mm long, attached 25–45 % from the lemma base; palea 2.0–3.5(–4.0) mm long overall, narrowly and shortly bifid at the apex (points to 0.3(–0.5) long); rachilla extension forming a plumose bristle 1.5–3.0(–3.5) mm long (including hairs); anthers 0.4–1.0(–1.2) mm long. **Salt Blown-grass.**

*Distribution:* Scattered in coastal areas from near Seaspray (south-eastern Victoria) westward to the Goolwa Barrage in South Australia, extending to c. 100 km inland on saline soils. Also scattered along the Tasmanian coastline, particularly on the east coast. (Fig. 9)

*Ecology:* See general notes on habitat and phenology following taxonomic section.

*Selected specimens examined:* **SOUTH AUSTRALIA:** Eight Mile Creek, 3 Feb. 1942, *Eardley* (AD); Lake Bonney, Barmera, 17 Feb. 1947, *Cleland* (AD); Goolwa Barrage, 6 Jan. 1950, *Cleland* (AD); Lake Eliza, Little Dip N.P., 9 Dec. 1975, *Brock 239* (AD); *Alcock 33* (AD); Mongolata Hills, 27 May 1989, *Bates 18551* (AD); between Gulnare and Spalding, 16 Nov. 1989, *Bates* (AD); Avenue, 25 Jan. 1999, *Brown 1570* (MEL, AD); Naracoorte, 25 Jan. 1999, *Brown 1572* (MEL, AD). **VICTORIA:** Glenthompson, 27 Jan. 1993, *Heard* (MEL); Skipton, 11 Jan. 1994, *Brown 870* (MEL); Lake Corangamite, North Cundare, 16 Dec. 1994, *Brown 973* (MEL); Woodbourne, 4 Jan. 1996, *Brown 1130* (MEL); Ross Bridge, 8 Jan. 1996, *Brown 1149* (MEL); Murtagurt Swamp, Barwon Heads, 24 Dec. 1996, *Brown 1223* (MEL); Honeysuckle Estate, Seaspray, 17 Dec. 1998, *Brown 1527* (MEL). **TASMANIA:** mouth of Boomer Creek, 12 Jan. 1941, *Curtis* (HO, MEL); St. Helens, 24 Dec. 1959, *Burns 213* (HO); Point Lesueur, Maria Is., 12 Dec. 1977, *Brown 334 & 449* (HO); Bathurst Harbour, Celery Top Islands, 12 Apr. 1978, *Kirkpatrick* (HO); Calverts Lagoon, South Arm, 4 Feb. 1979, *Morris 79104* (HO, MEL); Gull Reef, Port Davey, 10 Feb. 1980, *McKendrick* (HO); mouth of Harcus River, 27 Dec. 1986, *Buchanan 8973* (HO); 4 km west of Harley's Point, Cape Barren Is., 12 Dec. 1988, *Buchanan 11142* (HO); Cape Portland near Cape Lagoon, 7 Jan. 1993, *Steane* (HO).

**4. *Agrostis punicea*** A.J. Brown & N.G. Walsh *Nom. et stat. nov.* Type: Tasmania, New Norfolk, 15 Nov. 1840, *Ballantine 1446* (holotype K; isotype HO). *Agrostis billardierei* R. Br. var. *setifolia* Hook. f., *Fl. Tas.*, 2: 115 (1860). *Agrostis aemula* R. Br. var. *setifolia* (Hook.f.) Vickery *Contr. New South Wales Natl Herb.* 1: 116 (1941).

Bluish-green, tufted, glabrous, short-lived *perennial*, 20–65 cm tall (including inflorescences); culms erect, 10–30(–45) cm tall. *Leaf* blades rather stiff, scabrous, conduplicate to pseudo-convolute (sometimes becoming involute on drying); basal leaves (generally forming an erect to spreading tussock) 5–25(–35) cm long, 0.2–1.0 mm wide; flag leaves 1.5–10 cm long, 0.2–0.5(–1.0) mm wide; ligules obtuse, 2–8 mm long. *Inflorescence* a fine, open panicle with erect to spreading branches, 10–25(–30) cm long, 5–30 cm wide, generally well exerted from the upper leaf sheath; peduncle 2–20 (–25) cm long; 2–5 branches in the lowest whorl; branches and pedicels very fine, often pinkish-purple to reddish-purple; spikelets rather few, generally not overlapping, widely gaping. *Spikelets*

4.5–7.0 mm long overall (excluding awn); usually purple to dark purple; glumes acuminate and keeled (occasionally the keel extending to a fine seta 0.4 mm long), subequal, moderately scabrous along the keel but smooth on sides (occasionally lightly and distally scaberulous), margins entire or occasionally with a few scattered cilia; lemma 3.0–5.0(–5.5) mm long overall, with 2–4 setae at apex 0.5–1.5 mm long; awn bent, attached 10–20(–25) % from the lemma base and often (particularly when immature) lying in a groove of the lemma along the central nerve; palea 2.5–4.5 mm long overall, narrowly bifid at the apex (points 0.3–)0.4–1.2 mm long); rachilla extension forming a plumose bristle (1.5–)2.0–3.5 mm long (including hairs); anthers 0.8–1.7(–2.1) mm long.

**Purple Blown-grass.**

*Etymology:* The epithet, meaning reddish-purple in Latin, refers to the colour of the panicle branches which is conspicuous on flowering plants. The epithets *filifolia* and *setifolia* which might otherwise have been chosen are preoccupied at species level within *Agrostis*.

#### 4a. *Agrostis punicea* var. *punicea*

*Lemma* covered in lower three-quarters with hairs, upper nerves and setae finely scabrous. Awns 7.5–12.5 mm long. The sizes of glumes, lemmas, paleas and rachilla extensions (including hairs) do not occur in the bottom 20 % of each range for the species.

*Distribution:* Scattered across the volcanic plain and Dundas Tableland of south-west Victoria, extending into south-east South Australia with isolated occurrences in near-coastal south Gippsland. Also scattered in the Tasmanian midlands. (Fig. 10)

*Ecology:* See general notes on habitat and phenology following taxonomic section.

*Selected specimens examined:* **SOUTH AUSTRALIA:** Cooloolie, 11 Nov. 1945. Crocker (AD);



**Figure 10.** Distribution map of known collections of *Agrostis punicea* var. *punicea* (syn. *Agrostis aemula* var. *setifolia*) in SE Australia.

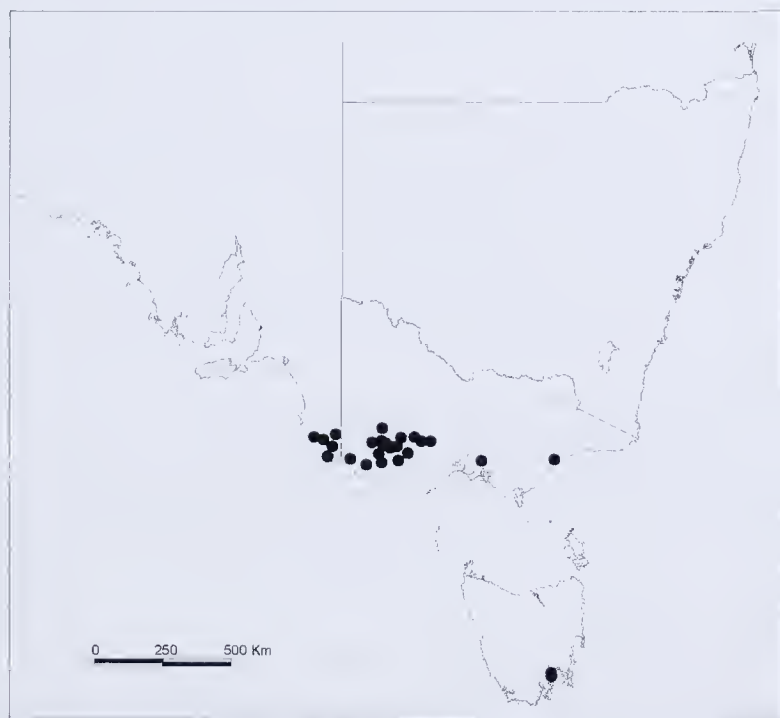
Marshes Swamp, between Glencoe and Mt. Burr, 19 Jan. 1969, *Wilson 970* (AD); Tantanoola Forest, 23 Nov. 1991, *Bates 26388* (AD). **VICTORIA:** Steep Bank Creek, 1 Nov. 1982, *Corrick 8473* (HO, MEL); Hamilton, 3 Nov. 1982, *Corrick 8544* (HO, AD); Buckleys Swamp, 22 Dec. 1986, *Brown 72B* (MEL); Craigieburn, 10 Nov. 1989, *Frood* (MEL); Mullungdung State Forest, 2 Nov. 1995, *Paget 1609* (MEL); 12 km north of Sale, 27 Oct. 1997, *Paget 2941* (MEL); Beeac, 7 Dec. 1995, *Brown 1014* (MEL); Hexham, 15 Dec. 1995, *Brown 1047* (MEL); Mt. Pollock, 3 Dec. 1997, *Brown 1384* (MEL); Byaduk, 5 Dec. 1997, *Brown 1438* (MEL); Ripponhurst, 5 Dec. 1997, *Brown 1445* (MEL); Digby, 3 Dec. 1998, *Brown 1512* (MEL); Jack Smith Lake, Darriman, 31 Dec. 1998, *Brown 1543* (MEL); Coojar, 25 Jan. 1999, *Brown 1575* (MEL). **TASMANIA:** Penquite, 9 Dec. 1844, *Gunn 592* (K); Ulverstone, 1912, *Burbury* (HO); 7 km west of Ross, 10 Dec. 1984, *Fensham* (HO); Epping Forest, Rowranna, 14 Dec. 1984, *Fensham* (HO); Shooters Hill, 22 Dec. 1984, *Fensham* (HO); 1.5 km north-west of Pringle Hills, 24 Dec. 1984, *Fensham* (HO).

**4b. *Agrostis punicea* var. *filifolia*** A.J. Brown & N.G. Walsh *comb. nov.* *Agrostis billardierei* R.Br. var. *filifolia* Vickery, *Contr. New South Wales Natl Herb.* 1: 110 (1941). *Type:* Victoria, Hawkesdale, Dec. 1901, *Williamson* (holotype K).

*Lemma* hairless except for callus tuft, covered with very fine to microscopic papillose-scabrid projections, upper nerves and setae finely scaberulous. Awns 6.0–10.0 mm long. The sizes of glumes, lemmas, paleas and rachilla extensions (including hairs) cover the full range for the species.

*Distribution:* Scattered in the western half of south-west Victoria and extending into south-east South Australia with isolated occurrences at Lyndhurst and Meerlieu in Gipspsland. Also two old records from near Hobart in Tasmania. (Fig. 11)

*Ecology:* See general notes on habitat and phenology following taxonomic section.



**Figure 11.** Distribution map of known collections of *Agrostis punicea* var. *filifolia* (syn. *Agrostis billardierei* var. *filifolia*) in SE Australia.

*Selected specimens examined:* **SOUTH AUSTRALIA:** near Mt. Gambier, 1880, *von Mueller* (MEL); Yallum and Beachport, Oct. 1883 (AD); Wooleys Lake, Beachport (?), Oct 1883 (AD); Pcnola, 27 Oct. 1945, *Survey team* (AD). **VICTORIA:** Buckleys Swamp, 22 Dec. 1986, *Brown* 72A (MEL); Connover Swamp, Drik Drik, 3 Dec. 1992, *Albrecht* 5159 (MEL, AD, HO); 12 km east of Woorndoo, 3 Dec. 1992, *Albrecht* 5189 (MEL); Lyndhurst, 19 Nov. 1993, *Costello s.n.* (MEL); Glenthompson, 10 Jan. 1994, *Brown* 827 (MEL); Hexham, 15 Dec. 1995, *Brown* 1046 (MEL); Hadden, 4 Jan. 1996, *Brown* 1123 (MEL); Lake Goldsmith, Stockyard Hill, 6 Dec. 1996, *Brown* 1189 (MEL); north of Karabeal, 13 Dec. 1996, *Brown* 1204 (MEL); Lake Repose, Glenthompson, 30 Dec. 1996, *Brown* 1246 (MEL); Dunkeld, 30 Dec. 1996, *Brown* 1241 (MEL); south of Bulart, 31 Dec. 1996, *Brown* 1270 (MEL); Moutjup, 14 Nov. 1997, *Brown* 1341 (MEL); Ballyrogan, 23 Dec. 1997, *Brown* 1473 (MEL); Homerton, 3 Dec. 1998, *Brown* 1517 (MEL); Meerlieu, 31 Dec. 1998, *Brown* 1539 (MEL). **TASMANIA:** Blackman's Bay, Feb. 1929, *Rodway* (HO); Hobart, 1929, *Rodway* (HO).

#### NOTES ON RELATED TAXA

*Lachnagrostis tenuis* (Cheeseman) Edgar, *New Zealand J. Bot.* 33: 30 (1995). *Deyeuxia billardierei* (R. Br.) Kunth, var. *tenuis* Petrie ex Cheeseman, *Man. N.Z. Fl.* 870 (1906). *Type:* New Zealand, Catlins River, Clutha Co., Otago, March 1896, *H.J. Matthews* (holotype WELT; isotypes AK, WELT, CHR).

The 'Blown-grasses' of New Zealand have been separated from *Agrostis* L. into *Lachnagrostis* Trin. (Edgar 1995). This genus has 12 New Zealand species, with 2 of these (*Lachnagrostis billardierei* (R. Br.) Trin. syn. *Agrostis billardierei* R. Br., and *L. filiformis* (G. Forst) Trin. syn. *Agrostis avenacea* J.F. Gmel.) also found in Australia. Another species, *Lachnagrostis tenuis* (Cheeseman) Edgar which is not known from Australia, has many morphological characters in common with *Agrostis robusta*. In particular, it has narrow, strongly involute leaves and scaberulous lemmas. In general appearance, *L. tenuis* resembles smaller and less mature forms of *A. robusta* with its relatively small stature (20–30 cm tall) and short leaves (5–15 cm). It differs principally in its smaller and only partly spreading inflorescences (5–10 cm long, 5–10 cm wide) that are almost always enclosed at the base by the leaf sheath, and its shorter (1–2 mm long) ligules. Further, the lemma surface of *L. tenuis* is almost completely covered with strongly scaberulous projections, whereas *A. robusta* is mainly scaberulous in the distal half only. *Lachnagrostis tenuis* has only been recorded from near-coastal latitudes south of 43° (Canterbury on South Island) whereas *Agrostis robusta* extends from 43° (southern Tasmania) to 33° (North Lofty Region of South Australia). However, like *A. robusta*, it is recorded as growing in salt marshes and tidal ground. Further study is needed before a definite conclusion can be reached on the correct placement of these taxa. Research on the generic limits of *Agrostis* and related genera (in particular, *Deyeuxia*) are in progress (S.L.W. Jacobs, New South Wales Herbarium, pers. comm.) and the results of this study may recommend the transferral of several native taxa into other genera. This work should include a reassessment of *A. robusta* and *L. tenuis*. Current knowledge suggests that these two entities could be recognised at infraspecific rank only.

*Specimens examined:* **NEW ZEALAND, SOUTH IS.** Catlins River, Otago, *D. Petrie*, Mar. 1896 (WELT); Fortrose, Southland, *D. Petrie*, 4 Jan. 1913 (WELT); Lyttleton Harbour near Teddington., 2 Jan. 1966 (CHR); **STEWART IS.** Near head of South-west Arm, H.D. Wilson and C.D. Meurk, 18 Feb. 1980 (CHR).

#### Growth Habit and Habitat

##### GENERAL OBSERVATIONS

*Agrostis billardierei* var. *tenuiseta* has a very similar growth appearance to var. *billardierei* except that it appears to have a greater tendency to produce rhizomes. This habit is particularly noticeable where the taxon is growing on deep wind-blown sand, such as on the edge



of the seaward side of a sand dune. In Tasmania, var. *tenuiseta* has only been found, thus far, growing in stands of the introduced *Ammophila arenaria*, close to the beach, either on or between the first two or three sand dunes. In contrast, var. *billardierei* tends to grow in more sheltered positions, such as in tall grass or shrub communities in the depressions between sand dunes, on grassy (*Poa*, *Austrostipa* spp.) flats behind the sand dune complex or in cliff-top coastal scrub. Where it occasionally grows in more exposed positions, it is generally stunted and inflorescences ripen before exsertion from the leaf sheaths.

Observations of growth habit for *A. billardierei* var. *billardierei* and *A. robusta* have found that contrary to published descriptions (as *A. billardierei* var. *robusta*), *A. robusta* is more likely to have a less rigid habit than *A. billardierei*. However, habit is variable, depending on habitat. Where *A. billardierei* is found growing in more exposed situations or on saline flats, leaves, culms and mature panicles tend to be erect and rather stiff, compared to the more lax leaves and ascending culms of the smaller plants growing in the shelter of *Leptospermum*/*Acacia* thickets. *Agrostis robusta* can form erect and dense tussocks where soil moisture levels are more or less permanent, but generally it occurs as a weeping tussock with few culms. In both habitats, the leaves and panicles are more or less lax until the onset of senescence. *Agrostis robusta* is always found on saline flats or marshes and often in association with other salt-tolerant species such as *Puccinellia* spp., *Juncus kraussii*, *Plantago coronopus*, *Triglochin striata* and *Sarcocornia quinqueflora*.

*Agrostis punicea* var. *punicea* and var. *filifolia* have a similar range of habitats and are sometimes found mixed together in the same population. Their appearance in the field is identical and only examination of the lemma can discern the difference. Their fine, waving panicles can often be overlooked in a field of other grasses and herbs, unless they are a dominant species in the community. These taxa have been found growing in moist depressions in grasslands of *Themeda*, *Austrostipa* and *Austrodanthonia* spp., on the edges of non-saline swamps and on saline flats.

*Agrostis collicola* has been collected from exposed situations with little vegetation or from herb lawns on stream banks (Morris 1990).

## SOIL CHARACTERISTICS

Table 4 shows soil analysis data for a range of *A. billardierei* var. *billardierei*, *A. robusta* and *A. punicea* sites sampled during January 1998 or 1999. Surface soil textures vary widely for each taxon. Means of electrical conductivity (and calculated total soluble salts) and soil moisture contents are similar for *A. billardierei* var. *billardierei* and *A. punicea* with data for both taxa ranging from low to moderate levels. Soil salts and moisture means and ranges for *A. robusta* are considerably higher than for the other two taxa. However, soil pH means (moderately alkaline) and ranges for *A. robusta* are similar to *A. billardierei*, while *A. punicea* has a lower mean value (slightly acid).

**Table 4:** Range in soil texture, mean and range in soil pH in water (pH<sub>w</sub>), electrical conductivity (EC) dS/m, total soluble salts (TSS) % and moisture content on dry soil basis (M<sub>d</sub>) % for various *Agrostis* spp. sites, sampled in January 1998 and 1999.

Taxa	No. sites	Soil texture range	pH <sub>w</sub>	EC	TSS	M <sub>d</sub>
<i>A. billardierei</i> var. <i>billardierei</i>	6	sandy loam to light clay	8.3 (6.8–9.6)	0.73 (0.15–1.7)	0.22 (0.04–0.50)	30 (11–48)
<i>A. robusta</i>	7	fine sandy clay loam to light clay	8.0 (7.7–8.7)	2.9 (1.5–5.7)	0.85 (0.45–1.7)	89 (46–269)
<i>A. punicea</i> var. <i>filifolia</i>	5	organic loam to light medium clay	6.5 (5.7–8.7)	0.74 (0.11–2.0)	0.22 (0.03–0.60)	38 (15–52)

## PHENOLOGY

Inflorescence emergence and maturing for all taxa varies according to environmental conditions but some general observations can be made. *Agrostis punicea* plants tend to mature earlier than those of *A. billardierei* var. *billardierei* or *A. robusta* but similar to *A. aemula*. In general, inflorescences of these taxa can start to appear during late October, are fully expanded by mid November and have mostly disarticulated by the end of December. Inflorescences of *A. billardierei* var. *billardierei* become noticeable during mid to late November and are mature by the end of December, although some younger panicles may also emerge at this time if conditions are favourable. *Agrostis robusta* generally does not show any inflorescences until mid December with new inflorescences emerging right up to the end of March if soil moisture is adequate. Maturity generally peaks around mid February.

## LONGEVITY

The percentage of tussocks tagged in January 1998 that survived (i.e. grew new shoots and developed new inflorescences) through to January 1999 varied from site to site. For the two sites of *Agrostis robusta*, results were 44% and 100% survival. Survival rates dropped to 13% and 50% respectively over the following season. The latter site borders an area inundated with water all year except for mid summer, although even at that time, the soil remains wet. The former site, while remaining moist, is drier over the summer. Results of tussock survival for *A. punicea* were 80% and 100% after the first season but only 47% and 15% respectively after the second season. Both these taxa appear to be short-lived perennials, given favourable conditions. A few tussocks marked at two sites of *A. billardierei* var. *billardierei* were still growing vigorously when observed two years later and attest to the perennial nature of this taxon.

## Acknowledgments

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**Appendix 1.** Morphological plant characters measured and used in statistical analysis.

Plant part	Measured and derived characters	Multivariate analysis	Variable type
Total	Total height (Hgt)	Yes	*C
	Basal tussock height (Llh)	Yes	C
	% basal to total height (Llhp)	No	C
	Culm height (Ch)	Yes	C
	% culm to total height (Chp)	No	C
Leaves	Inrolling or folding (Lr)	Yes	**D (1-5)
	Basal width (Llw)	Yes	C
	Flag width (Lfw)	Yes	C
	Flag length (Lfh)	Yes	C
	Ligule length (Lig)	Yes	C
Infloresc.	Extension from leaf sheath (le)	Yes	D (1-4)
	Length of visible peduncle (Ipd)	Yes	C
	No. of visible branches in lowest whorl (Ilb)	No	C
	Height from lowest whorl (Ih)	Yes	C
	Width (Iw)	Yes	C
	Height to width ratio (Ih:Iw)	No	C
	Stiffness (Ia)	Yes	D (1-4)
	Pediceal colour (Ipc)	No	D (1-5)
	Spikelet clustering (Sa)	Yes	D (1-3)
Spikelet	Outer glume colour (Sc)	No	D (1-5)
	Glume gape (Sg)	Yes	D (1-4)
Lower glume	Total length (Glt)	No	C
	Body length (Glb)	Yes	C
	Setae length (Gls)	Yes	C
	% setae of total length (Glsp)	No	C
Upper glume	Total length (Gut)	No	C
	Body length (Gub)	Yes	C
	Setae length (Gus)	Yes	C
Both glumes	Scabridity of keels (K)	Yes	D (0-3)
	Ciliation of margins (M)	Yes	D (0-2)
	Total length ratio (Glt:Gut)	No	C
Lemma	Total length (Lt)	No	C
	Body length (Lb)	Yes	C
	Setae length (Ls)	Yes	C
	% setae of total length (Lsp)	No	C
	Density of back hairs (B)	Yes	D (0-4)
	Coarseness of scabrid surface (Rc)	Yes	D (0-3)
	Density of scabrid surface (Rd)	Yes	D (0-3)
Palea	Total length (Pt)	No	C
	Body length (Pb)	Yes	C
	Setae length (Ps)	Yes	C
	% setae of total length (Psp)	No	C

Rachilla extension	Total length incl. hairs (Re)	Yes	C
Awn	Total length (At)	No	C
	Column length (Ac)	Yes	C
	Bristle length (Ab)	Yes	C
	% bristle of total length (Abp)	No	C
	Awn attachment height from lemma base (Aa)	Yes	C
	% awn attachment of total length (Aap)	No	C
Anther	Total length (A)	Yes	C

\* C = continuous variable, \*\* D = discrete variable [ordinal scales for discrete variables: Lr: 1 = flat, 2 = flat and involute (as a result of drying out), 3 = flat and conduplicate (may become pseudo-convolute and/or slightly involute with age), 4 = conduplicate, 5 = convolute to strongly involute; le: 1 = not exerted or spreading, 2 = not exerted but spreading, 3 = not fully exerted but more or less fully spread, 4 = fully exerted; la: 1 = very stiff and erect, 2 = rather stiff and more or less erect, 3 = not stiff but erect to slightly drooping, 4 = lax and weeping; lpc and Sc: 1 = light green, 2 = mid-green, 3 = greyish green (green with minute purple mottling), 4 = mid-purple, 5 = dark purple to reddish purple; Sa: 1 = spikelets overlapping and obscuring individuals, 2 = spikelets partly overlapping but individuals discernible, 3 = spikelets more or less separate without overlapping; Sg: 1 = nil or scarcely gaping outer glumes, 2 = slightly gaping outer glumes (up to 10°), 3 = moderately gaping outer glumes (10° to 30°), 4 = widely gaping outer glumes (> 30°); K: 0 = non scabrous, 1 = slightly scabrous, 2 = moderately scabrous, 3 = strongly scabrous (often with scaberulous sides as well); M: 0 = non ciliate, 1 = minutely or distantly ciliate, 2 = uniformly ciliate; B: 0 = non-hairy, 1 = occasional hairs only, 2 = slightly or distantly hairy, 3 = covered in hairs but surface still discernable, 4 = covered in hairs and surface obscured; Re: 0 = no bristles (but may be villous), 1 = minutely scaberulous, 2 = finely scaberulous, 3 = strongly scaberulous; Rd: 0 = not scaberulous (but villous), 1 = lightly scaberulous (generally scattered on central nerve of lemma and setae only), 2 = moderately scaberulous (generally upper lemma back, central nerve and setae only), 3 = densely scaberulous (upper lemma back, central nerve and setae to total lemma surface)].



## Two new species of *Thelymitra* (Orchidaceae) from southeastern Australia

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### Abstract

*Thelymitra atronitida* and *Thelymitra planicola* from southeastern Australia are described as new and illustrated. Their distribution, habitat, biology and conservation status are discussed. *Thelymitra atronitida* is a member of the complex of taxa surrounding *Thelymitra uuda* R. Br., its closest congener being *Thelymitra malvina* M.A. Clem., D.L. Jones & Molloy. *Thelymitra planicola* bears a superficial likeness to *Thelymitra pauciflora* R. Br. and *Thelymitra aristata* Lindl., and its possible relationship to these species is discussed. A key is provided to distinguish the new taxa from other members of the *Thelymitra nudalpauciflora* complex in southeastern Australia.

### Introduction

*Thelymitra* J.R. Forst. *et* G. Forst. is a large and complex genus consisting of about 70 described species, several described natural hybrids and an uncertain number of undescribed taxa. It is mainly concentrated in higher rainfall areas of temperate Australia, but a few species occur in tropical northeastern Australia, about 10 endemic species occur in New Zealand and four additional species occur in Indonesia, New Caledonia, New Guinea and the Philippines. While examining preserved and living plants as part of a revision of *Thelymitra* for Victoria (in preparation), it became evident that several distinct undescribed taxa exist in Victoria and at least some of these probably extend to neighbouring States. Due to a paucity of collections and several poor flowering seasons because of drought, some suspected undescribed taxa have not yet been satisfactorily studied and assessed, hence their status remains unresolved. However, this opportunity is taken to describe two new species that have been reasonably well collected in recent years, and are familiar to me from herbarium material as well as from living plants *in situ*.

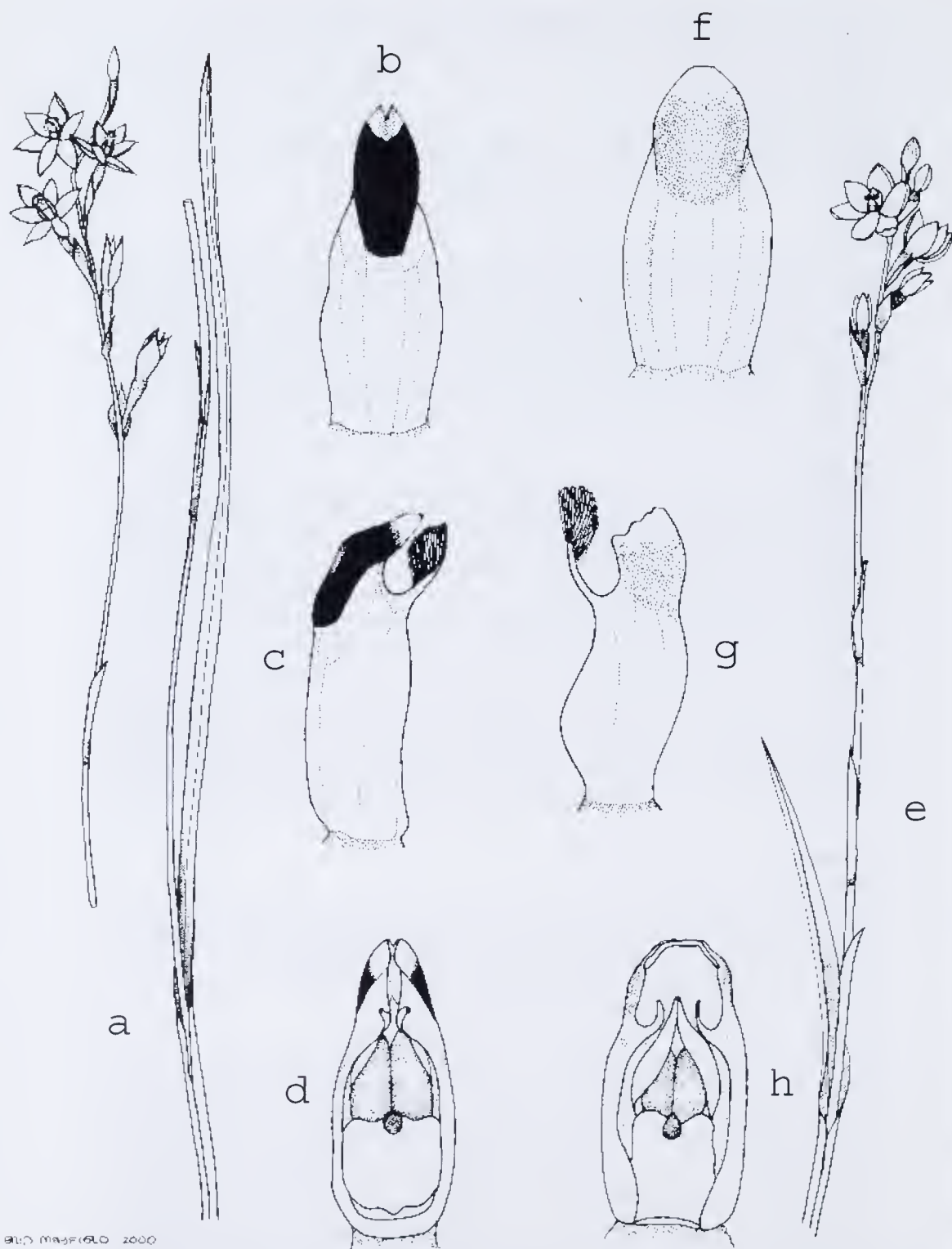
### Taxonomy

*Thelymitra atronitida* Jeanes, *sp. nov.*

*Thelymitra malvinae* M.A. Clem., D.L. Jones *et* Molloy affinis bracteis sterilibus duabus plerumque, floribus paucioribus autofertilibus facultative, lobo post-antheram atronitido plerumque, pilis caespitosis loborum lateralium albeis differt.

Type: Victoria. Beside Genoa Creek Track, c. 4 km WSW of Genoa, 27. x. 1999, J.A. Jeanes 613 (holotype MEL 2069953, isotype CANB).

Glabrous terrestrial *herb.* Tubers not seen. *Leaf* linear to linear-lanceolate, 15–35 cm long, 5–12 mm wide, erect, leathery, canaliculate, dark green with a purplish base, ribbed abaxially, sheathing at base, apex acute. *Scape* 30–50 cm tall, 1.5–3.5 mm diam., straight, straw-coloured to purplish. *Sterile bracts* usually 2, occasionally 3, linear to linear-lanceolate, 1.5–7 cm long, 3–10 mm wide, green or purplish, acute to acuminate. *Fertile bracts* ovate-acuminate to obovate-acuminate, 5–25 mm long, 3–8 mm wide, green or purplish, sheathing pedicels. *Pedicels* 5–12 mm long, slender. *Ovary* cylindric to narrow-obovoid, 5–12 mm long, 2–4 mm wide. *Flowers* 2–8, (14–)20–26 mm across, moderately dark blue with darker longitudinal veins, opening readily only in hot weather. *Perianth segments* (7–)10–13 mm long, 3–8 mm wide, concave, often shortly apiculate; *dorsal sepal* ovate to elliptic; *lateral sepals* elliptic to lanceolate, slightly asymmetric; *petals* ovate to



**Figure 1.** *Thelynittra atronitida*: a habit ? 0.5; b column from rear ? 6; c column from side ? 6; d column from front ? 6. *Thelynittra planicola*: e habit ? 0.5; f column from rear ? 6; g column from side ? 6; h column from front ? 6.

elliptic; *labellum* elliptic to lanceolate, often narrower than other segments; *column* erect from the end of ovary, 5.5–7 mm long, 2.5–3.5 mm wide, mostly pale blue; *post-anther lobe* 3–4 mm long, 1.5–2.5 mm wide, tubular, inflated, hooded, dorsally compressed, gently curved through c. 90°, apex shortly bilobed, lobes toothed, mostly glossy black, apex yellow; *auxiliary lobes* absent; *lateral lobes* 1.3–1.5 mm long, filiform, porrect at base then bent sharply upwards at about the middle, converging, each with a terminal toothbrush-like arrangement of white trichomes, the individual trichomes 1.2–1.6 mm long. *Anther* ovoid 2.6–3.3 mm long, 1.2–2.2 mm wide, with a short beak 0.5–0.8 mm long, situated towards apex of column; *pollinarium* 2–2.5 mm long; *viscidium* more or less circular, c. 0.5 mm diam.; *pollinia* white, friable, mealy. *Stigma* ovate-quadrate, 1.7–2.5 mm long, 1.8–2.2 mm wide, margins irregular, situated at base of column. *Capsules* obovoid, 12–15 mm long, 4–6 mm wide, erect, ribbed. (Fig. 1. a–d; Fig. 3)

*Specimens examined*: **VICTORIA**: Between Jones Creek Track and private property, W of Genoa River, 7. xi. 1970, A.C. Beaglehole 34425 (MEL 652511); Near the intersection of East Wingan Rd and Princes Hwy. 24. x. 1999, J.A. Jeanes 643 (MEL 2069956); On rail reserve near Darlimurla Station, 29. x. 1999, J.A. Jeanes 636 (MEL 2069955); East Wingan Rd c. 500 m from Princes Hwy, 27. x. 1999, J.A. Jeanes 615 (MEL 2069959)

*Distribution and habitat*: East Gippsland and Gippsland Highlands Natural Regions (Conn 1993). Currently known from a few sites in eastern Victoria, mostly in the Mallacoota/Genoa area of far East Gippsland, with an outlying more westerly population near Mirboo North in the Strzelecki Ranges (Fig. 2). Grows in heathy open forest, usually around the margins of grassy plains, on well-drained sand or clay loams. A range extension into nearby southeastern New South Wales is anticipated, as similar habitat is known to occur there. Altitude: 5–200 m.

*Conservation Status*: Poorly known; suggest 3KC by criteria of Briggs & Leigh (1996).

*Flowering period*: Late October to early November.



Figure 2. Distribution of *Thelymitra atronitida*



Figure 3. *Thelymitra atronitida*  
Mallacoota area

**Biology:** This species is facultatively autogamous.

**Notes:** *Thelymitra atronitida* is part of the complex assemblage of taxa surrounding *Thelymitra mnda*, a species that has been variously circumscribed by modern flora writers (Bernhardt 1993; Weber & Entwisle 1994) and orchid specialists (Jones 1988; Bates & Weber 1990; Backhouse & Jeanes 1995; Bishop 1996). The type of *T. mnda* comes from northern Tasmania (Western Arm of Port Dalrymple), and a re-examination of this material forms the basis of a narrower circumscription of the taxon by Jones & Clements (1998) (see also Jones *et al.* 1999). *Thelymitra mnda sensu stricto* occurs on the Australian mainland (Jones *et al.* 1999), and I have seen plants in Victoria (eg. near Omeo) that conform to the new circumscription of the species. However, at present the distribution of *T. mnda* in Victoria is unknown, due largely to confusion with other related taxa. For example, the illustration on page 354 of Backhouse & Jeanes (1995), supposedly depicting *T. mnda*, probably represents an undescribed taxon related to *Thelymitra megalyptra* Fitzg.

*Thelymitra atronitida* differs from *T. mnda sensu stricto* in its darker blue, more prominently veined, autogamous flowers, and inflated, dorsally compressed, shortly bilobed, predominantly glossy black column post-anther lobe. The two species do not grow sympatrically. *Thelymitra atronitida* closely resembles *Thelymitra malvina*, but the former usually has only two sterile bracts (usually three in *T. malvina*), fewer, generally smaller flowers that are autogamous (entomophilous in *T. malvina*), a column post-anther lobe that is mostly glossy black (mostly brownish in *T. malvina*) and white hairs tufts on the lateral-lobes (mauve or pink in *T. malvina*). *Thelymitra malvina* is widely distributed from southeastern South Australia to southeastern Queensland (including Tasmania and New Zealand) and occasionally grows sympatrically with *T. atronitida*.

**Etymology:** From the Latin *ater*, black; *nitidus*, shining; in reference to the column post-anther lobe that is predominantly glossy black.

***Thelymitra planicola* Jeanes, *sp. nov.***

*Thelymitra pauciflorae* R. Br. affinis bractea sterili inferna foliiformi plerumque, lobo post-antheram breviori subcylindrico truncato, lobis lateralibus longioribus differt.

**Type:** Victoria. Golden Beach. SE edge of Lake Recve, 26. x. 1999, J.A. Jeanes 608 (holotype MEL 2069957, isotypes MEL 2069958, CANB).

Glabrous, somewhat glaucous terrestrial *herb*. *Tubers* not seen. *Leaf* linear to linear-lanceolate, 10–30 cm long, 5–20 mm wide, erect, leathery, canaliculate, dark green with a purplish base, ribbed abaxially, sheathing at base, apex acute. *Scape* 22–45 cm tall, 2–5 mm diam., straight, purplish. *Sterile bracts* 2–4, linear to lanceolate, 2–8 cm long, 5–15 mm wide, green or purplish, lower ones often leaf-like, closely sheathing for most of length, acute to acuminate. *Fertile bracts* ovate-acuminate to obovate-acuminate, 10–20 mm long, 4–8 mm wide, green or purplish, sheathing pedicels. *Pedicels* 1–8 mm long, stout. *Ovary* cylindric to narrow-obovoid, 3–12 mm long, 1.5–4 mm wide. *Flowers* 2–12, (15–)20–25(–30) mm across, medium blue with darker blue longitudinal veins, opening readily only in hot weather. *Perianth segments* (7–)10–13(–15) mm long, 4–8 mm wide, concave, often shortly apiculate; *dorsal sepal* ovate to obovate; *lateral sepals* ovate-lanceolate, slightly asymmetric; *petals* ovate to obovate; *labellum* oblanceolate to obovate, often narrower than other segments; *column* erect from the end of ovary, 5–6 mm long, 3–4 mm wide, white to pale blue; *post-anther lobe* 1.5–2 mm long, 1.5–2 mm wide, hooding, semi-cylindric, gently curved, apex shallowly bilobed, lobes shallowly toothed, mostly dark blackish brown with a thin blue collar, apex yellow; *auxiliary lobes* absent; *lateral lobes* 1.2–2 mm long, linear, obliquely erect, curved, converging, each with a short, terminal, toothbrush-like arrangement of white trichomes, the individual trichomes 0.9–1.5 mm long. *Anther* ovoid, 2.7–4 mm long, 1.5–2.2 mm wide, basal part obscured behind stigma, with a short terminal beak c. 0.5 mm long; *pollinarium* 1.5–2.2 mm long;





Figure 4. Distribution of *Thelymitra planicola*



Figure 5. *Thelymitra planicola*, Golden Beach

*viscidium* circular, c. 0.5 mm diam.; *pollinia* white, friable, mealy. *Stigma* more or less quadrate, 2–2.5 mm long, 2–2.5 mm wide, margins irregular, situated at base of column. *Capsules* obovoid, 10–16 mm long, 3.5–7 mm wide, erect, ribbed. (Fig. 1. e–h; Fig. 5)

*Specimens examined*: **NEW SOUTH WALES**: Cultivated CANB *ex* Orient Point, E of Nowra, 4 xi. 1988, D.L. Jones 3422 (CANB 8807085.1 & CANB 8807085.2). **VICTORIA**: Gippsland Lakes Coastal Park, 27. x. 1983, A.C. Beaglehole 74832 & W.R. Beaglehole (MEL 1531699); Gippsland Lakes Reserve, 27. x. 1984, A.C. Beaglehole 78814 & J.R. Turner (MEL 669448); Providence Ponds Flora and Fauna Reserve, 22. x. 1984, A.C. Beaglehole 78729 (MEL 670413); Gippsland Lakes Reserve, 27. x. 1984, A.C. Beaglehole 78799 & J.R. Turner (MEL 669443 & MEL 2069952); Lake Reeve, 1. xi. 1993, D. Rouse 4 (MEL spirit 2422A); Golden Beach, SE edge of Lake Reeve, 4. xi. 1996, J.A. Jeanes 258 (MEL 2034950, MEL spirit 4397B); Rail Reserve WSW of Lindenow South, 27. x. 1999, J.A. Jeanes 633 (MEL 2069954).

*Distribution and habitat*: Eastern Victoria and the central coast of New South Wales. Most collections are from the eastern section of the Gippsland Plain Natural Region (Conn 1993), between Sale and Bairnsdale, Victoria, with a single disjunct collection from near the New South Wales coast, east of Nowra (Fig. 4). Grows in herb-rich grassland and grassy woodland and heathland on soils ranging from sandy loams to clay loams. Altitude: 0–80 m.

*Conservation Status*: Poorly known; suggest 3KC by criteria of Briggs & Leigh (1996).

*Flowering period*: Late October to early November.

*Biology*: This species is facultatively autogamous.

*Notes*: *Thelymitra planicola* is a very distinctive species that is characterised by its overall glaucous appearance, moderately tall habit, large leaf-like lower sterile bracts, short pedicels, medium blue, longitudinally veined flowers mostly 20 to 25 mm across, and the short, semi-cylindric column post-anther lobe. The structure of the column post-anther lobe is not shared with any other members of the genus *Thelymitra*, so identification of fresh and spirit-preserved specimens is relatively simple. In the dried and pressed state however, *T. planicola* may be difficult to differentiate from *T. pauciflora*, although the persistent glaucous appearance of the leaf, scape, bracts and ovaries, and the often leaf-like lower sterile bracts are useful distinguishing characters. The structure of the

post-anther lobe of *T. planicola* is somewhat intermediate between those of *Thelymitra aristata* and *T. pauciflora*, but these two species have not been recorded growing sympatrically with *T. planicola*, so the latter is unlikely to be of hybrid origin.

*Etymology*: From the Latin *planum*, level ground, a plain; *cola*, inhabitant; in reference to the lowland plain habitat favoured by this species.

The following key is provided to distinguish the new species from other members of the *Thelymitra nuda/pauciflora* complex in southeastern Australia.

1. Column post-anther lobe semi-cylindric, widely open on the posterior side; lower sterile bracts often large and leaf-like ..... *T. planicola*
1. Column post-anther lobe tubular, narrowly open on posterior side; sterile bracts never large and leaf-like ..... 2
2. Column post-anther lobe not inflated, more or less continuous with basal part of column ..... 3
2. Column post-anther lobe inflated, discontinuous with basal part of column ..... 4
3. Flowers 20–25 mm across; hairs on lateral lobes in a toothbrush-like arrangement .... *T. uuda*
3. Flowers usually <20 mm across; hairs on lateral lobes in a mop-like arrangement .... *T. pauciflora*
4. Plants short and stout, clump-forming; flowers vivid mauve or purple with prominent darker longitudinal veins; basaltic grasslands of western Victoria. .... *T. gregaria*
4. Plants tall and slender, usually solitary; flowers pale to dark blue or pink, lacking prominent darker veins. .... 5
5. Column post-anther lobe not dorsally compressed; perianth segments often >15 mm long; mostly from dry inland habitats ..... *T. megalyptra*
5. Column post-anther lobe dorsally compressed; perianth segments usually <15 mm long; mostly from moist near-coastal forests ..... 6
6. Column post-anther lobe mostly glossy black with a yellow apex; hair tufts on column lateral lobes white; sterile bracts usually 2 ..... *T. atronitida*
6. Column post-anther lobe mostly brown with a yellow apex; hair tufts on column lateral lobes pink or mauve; sterile bracts usually 3 ..... *T. malvina*

### Acknowledgments

I am grateful to the Australian Orchid Foundation for their financial support of my work on *Thelymitra* during 1999. I wish to thank Dean Rouse for first bringing *Thelymitra planicola* to my attention in the early 1990's, and Allan Peisley and James Turner for supplying me with specimens of the new taxa. My colleague Neville Walsh (MEL) kindly wrote the Latin diagnoses and made helpful comments on the text. Thanks also to Enid Mayfield (MEL) for executing the line drawings, and the directors and curatorial staff at BRI, CANB, HO, NSW and MEL for access to specimens.

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***Spirogyra cardinia* (Zygnemataceae, Zygnematophyceae, Chlorophyta): a new species of freshwater alga from Victoria, Australia.**

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*Abstract*

*Spirogyra cardinia* (Zygnemataceae, Chlorophyta), a new species of freshwater alga from Victoria, Australia, in Section *Conjugata* (Vaucher) Hansg., *Punctata*-Group (Kadłubowska 1984) from the Cardinia Reservoir area in south-eastern Victoria, is described and illustrated. It is morphologically similar to *S. bellis* (Hassall) Cleve (which is in the *Maxima*-Group (Kadłubowska 1984)) and *S. occidentalis* (Transeau) Czurda (which is in the *Punctata*-Group (Kadłubowska 1984)) but differs in chloroplast number and vegetative filament and zygospore dimensions.

**Introduction**

Our recent census from literature records (Lewis & Entwisle 1998) accepted 31 species of *Spirogyra* Link from Australia, while Kadłubowska (1984), in the latest worldwide monograph of the genus, recognized 386 species in total. Since Kadłubowska's monograph, more than 30 new species have been described from around the world, yet none were from Australia. This paper describes a new species discovered as part of Australia-wide collecting for the preparation of an account of Zygnemataceae for the *Algae of Australia* project.

**Methods**

*Preparation of Material*

Specimens were preserved initially in 5% commercial formalin. After preparing dried specimens and permanent microscope mounts, the remaining material was transferred to 70% ethanol with 5% glycerol. For the microscope slides, specimens were stained with 1% aniline blue and placed in 10% Karo corn syrup with 0.25% phenol then mounted in 40% Karo corn syrup with 0.25% phenol.

**Taxonomy**

*Spirogyra cardinia* S.H. Lewis, sp. nov.

Cellulae vegetativae 42–156  $\mu\text{m}$  longae, 66–75  $\mu\text{m}$  latae, parietes extremi plani; chloroplasti 1(–2) anfracti 2–6-plo in cellulis; pyrenoides 5–15, 6  $\mu\text{m}$  latae. Conjugatio scalariformis, canibus ab utrinque cellulis formatis, extremitatibus tumidis. Gametangia (et cellulae steriles aliquot) in latera conjugationis inflata (75–90  $\mu\text{m}$  latae) abbreviata plerumque. Zygosporae ellipsoidea uniformes, 63–76  $\mu\text{m}$  longae, 36–48  $\mu\text{m}$  latae, exospora laeve incolorata, mesospora puncticulosa (punctula ad 1.5  $\mu\text{m}$  lata), aurea.

*Type:* Australia, Victoria, Narre Warren East, small pool near Kangaroo Flat Picnic Area, in Cardinia Reservoir Park, S.H.Lewis 403, 20.v.1998 (holotype MEL 2046440; isotype NSW).

*Vegetative cells* 42–156  $\mu\text{m}$  long, 66–75  $\mu\text{m}$  in diameter, length to diameter ratio = 1.15, with plane end walls; chloroplasts 1(–2), making 2–6 turns; pyrenoids 5–15, up to 6  $\mu\text{m}$  in diameter. Conjugation scalariform, conjugation tubes formed equally by both gametan-

gia and swollen where they meet; gametangia (and some sterile cells) inflated on the conjugation side to 75–90 µm and often shorter than the vegetative cells. *Zygospores* ellipsoid, uniform, 63–76 µm long, 36–48 µm in diameter, length to diameter ratio = 1.78, exospore smooth and colourless, mesospore finely punctate and golden brown to yellow, pits to 1.5 µm in diameter.

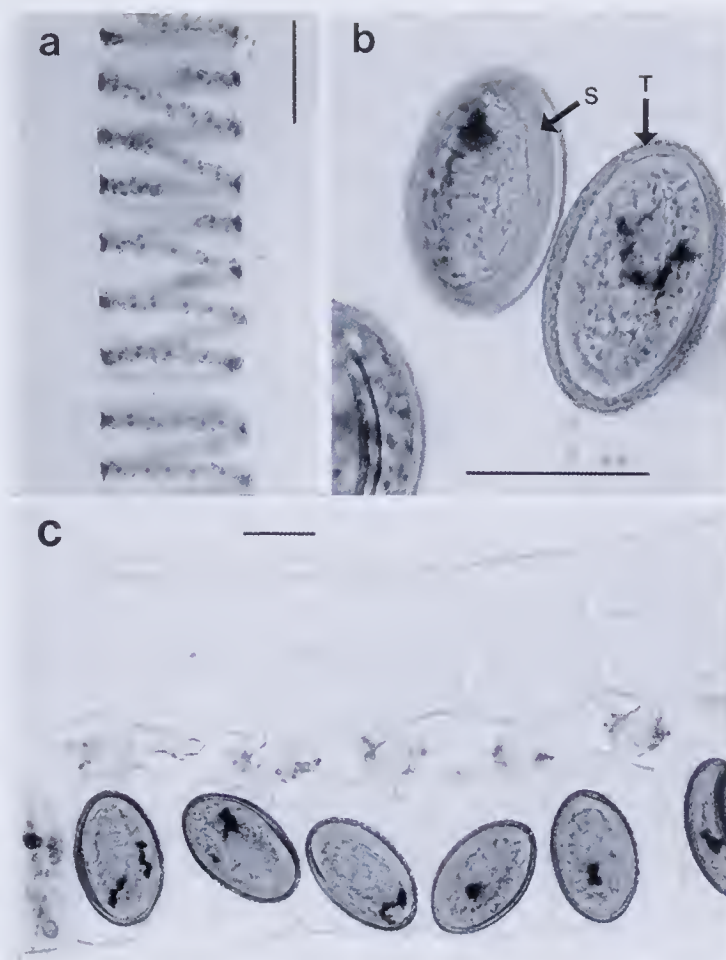
**Diagnostic Features:** *Spirogyra cardinia* belongs in the section *Conjugata* on the basis of its plane walls, and in the *Punctata*-Group on account of the mostly single chloroplast per cell and ornamented mesospore (Kadłubowska 1984). It differs from all other species in this group by having broader filaments (see Table 1 and Fig 1). In this group, *S. cardinia* is most similar to *S. occidentalis* (Transeau) Czurda in zygospore size (50–105 µm long, 36–61 µm in diameter in that species). However, *S. occidentalis* has much narrower vegetative cells (40–54 µm in diameter, although Czurda (1932 p.183, quoted in Kadłubowska 1984, p. 342) describes 'swollen barrel-shaped' cells) and gametangia that are cylindric or only inflated up to 66 µm. The orientation of the zygospores in *S. occidentalis* is parallel to the main axis, while that of *S. cardinia* is at 45–90 degrees, with only some parallel. From the illustrations of *S. occidentalis*, the new species also appears to have considerably shorter fertile and sterile cells.

*Spirogyra cardinia* is also comparable to *S. bellis* (Hassall) Cleve, from the *Maxima*-Group, a group comprising species with two or more chloroplasts and sculptured zygospore walls. The new species occasionally has cells with two chloroplasts, and *S. bellis* has similar vegetative filament dimensions. *Spirogyra bellis*, however, has 5–7 chloroplasts per cell and they are more spiralled (2–6 turns per cell cf. 1). It also has larger zygospores (64–105 µm long, 45–70 µm in diameter; Kadłubowska 1984) that are globose or lenticular rather than ellipsoid, the conjugation tubes are not swollen at the ends, and the gametangia are usually swollen on both sides or enlarged. No other species in the *Maxima*-Group are likely to be confused with *S. cardinia*.

*Spirogyra rugulosa* Iwanoff, in the *Punctata*-Group, is superficially very similar to the new species but the conjugation tubes are clearly formed by the male gametangia and the zygospores are broader. A recent collection (*S.H.Lewis* 718 (MEL)) from the type locality of *Spirogyra cardinia* has been referred to *S. rugulosa*. In this collection the wall was not as obviously punctate as that of the new species, although the vegetative filaments were similarly large. The conjugation tubes were, however, all definitely formed

**Table 1.** Comparison of *Spirogyra cardinia* with similar taxa and groups mentioned in the text. Data from Kadłubowska 1984 and current study.

Taxon	Veg. cells diam. µm	Zygospores diam. µm	Zygospores length µm	Chloroplast No.	Tubes formed by
<i>S. cardinia</i>	66–75	35–48	63–76	1(–2)	both gametangia
<i>Punctata</i> -Group	11–62	19–68	26–150	1(–3)	varies
<i>S. rugulosa</i> Iwanoff (Kadłubowska 1984)	45–62	45–55	27–90	1	male gametangia
<i>S. rugulosa</i> (S.H.Lewis 718)	63–78	42–48	66–78	1	male gametangia
<i>S. occidentalis</i> (Transeau) Czurda	40–54	36–61	50–105	1–3	both gametangia
<i>S. bellis</i> (Hassall) Cleve	65–80	45–70	64–105	5–6	both gametangia



**Figure 1** a–c *Spirogyra cardinia* sp. nov.; **a**. vegetative cells; **b**. zygospores showing mesospore ornamentation visible in transverse section (T) and surface view through exospore (S); **c**. conjugating cells. Scale: 40µm.

by the male gametangia and therefore matched those of *S. rugulosa*, whereas the tubes of the new species were all obviously formed by both gametangia. Both of these populations warrant further study.

**Distribution and Habitat:** *Spirogyra cardinia* is only known from the type collection. The pool was about 30 cm deep and 3 m in diameter and apparently permanent. Other collections from the same site, at the same time and at similar times in the following year, yielded a number of other species of *Spirogyra*, none of which resembled *S. cardinia*. *Spirogyra cardinia* was loosely associated with *Callitriche stagnalis* Scop., *Cyperus eragrostis* Lam. and *C. lucidus* R.Br., and with *Nitella leptostachys* A.Br. var. *leonhardii* (R.D.Wood) R.D.Wood.

**Etymology:** The epithet refers to the location from which it was collected.

**Conservation Status:** Using the criteria of Briggs and Leigh (1996) the Risk Code is assessed at 1K. Based on current collecting it is clearly rare, however, as with all the ephemeral Zygnemataceae, it may be widespread. Making decisions regarding the conservation status of algae in Australia is especially difficult due to a lack of distributional data, paucity of fertile (needed for identification) collections, changes to the fragile aquatic environments (Entwistle 1997) and the transient nature of *Spirogyra*.

## Discussion

Although this species is differentiated from the other species in the *Punctata*-Group (Kadłubowska 1984) by its vegetative cell dimensions, a character viewed as being influenced by polyploidy (Hoshaw *et al.* 1985, 1987; Hoshaw and McCourt 1988), this difference appears to be of such magnitude that the entity deserves to be recognized taxonomically. Furthermore, it differs from the most similar species, such as *Spirogyra bellis*, *S. rugulosa* and *S. occidentalis*, by a number of characters apparently less influenced by polyploidy, such as spore, gametangia and tube shape, chloroplast number and mesospore ornamentation.

## Acknowledgments

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## Book Review

**Flora of Australia, volume 12, Mimosaceae (excl. *Acacia*), Caesalpiniaceae.** Editor P.M. McCarthy. Published by CSIRO, Melbourne, 1998; 213 pp.; hardcover edition (ISBN 0 643 06298 X) \$AU 69.95; soft cover edition (ISBN 0 643 06299 8) \$AU 54.95

This volume, presents all the Caesalpiniaceae and Mimosaceae, excluding *Acacia*, native and naturalised in Australia. The Caesalpiniaceae are represented in our flora by 22 genera and 127 species; the Mimosaceae by 17 genera and well over 1000 species. This latter includes the most speciose of Australia's genera, *Acacia*, not treated in this volume. Without *Acacia*, the family is but sparingly represented, with only 43 species. Most of these grow in the wet tropical north (especially Queensland).

It is a disappointment to me that in this case *The Flora of Australia* is committed to following Cronquist's system of classification of the legumes, splitting them into three families. This, despite the confession of two of the contributors to this volume, that most specialists who study the group would include them in one family. Simply put, there are no characters that support Cronquist's classification. In fact two genera, *Pentaclethra* and *Dimorphandra*, though put in two different families by Cronquist (Mimosaceae and Caesalpiniaceae respectively) are more similar to each other than they are to any other member of their respective families. Though only a flora series, I think it unfortunate in this case that it was not decided to allow the nomenclature used to reflect our increased understanding of the systematics of the group, and to include all the legumes in one family. The editors have, in effect, perpetuated what appears to this legume researcher to be an anachronistic position. Though this is an important criticism to me, it in no way distracts from the practical value and presentation of this volume.

Seven authors contributed treatments to this book, and it is a credit to the editorial staff that they all conform to the same standard. In an afternoon in the herbarium using the keys with herbarium specimens I discovered no errors in fact, and hardly any difficulty in using them. Each couplet in the keys I used worked, and in most instances the authors are to be commended for using vegetative and reproductive characters in their couplets, thereby allowing one to identify specimens that might be fruiting or sterile.

Even though the descriptions are short, as is perhaps necessary in this series, in every one that I had to refer to, enough information was provided to clearly determine a specimen not determined for certain using the key.

I am sad to say that I did find some of the illustrations to be rather coarse and unappealing. I could not tell if this was the lack of finesse on the part of the artist, or if the line drawings were too reduced in reproduction. The line drawings are supplemented with some beautiful colour photographs (32 of mimosoids, and 32 of caesalps, each in eight plates). These photos are a wonderful addition, and bring to the fore characters that cannot be appreciated in reading the descriptions. For instance, the photo of the fruits of *Archidendron lucyi* (Fig. 21, p. xviii), *Aa. hendersonii* and *ramiflorum* (Fig. 19, 20, p. xvii) are stunning. Not only because of the unusual beauty of the fruit – all bright red with contrasting, dark seeds – but also because I was struck with the similarity of this fruit to some American genera of tribe Ingeae, like *Pithecellobium*, or *Abarema*; genera with which I am much more familiar. No description had ever conveyed that to me.

At first I was put off by the treatment of *Senna*, with its form taxa. Having known that B. Randell and B. Barlow had both worked on the groups for quite some time, I expected more. In hindsight though, after curating the collections at MEL, I see my attitude was a bit naïve. Though I would have theoretically admitted that there are groups so tokogenetically complex as to defy simple treatment, I had no personal experience with one. I see now, though, that *Senna* is such a group, and the treatment by Randell and Barlow seems rational and practical.

The contribution of the Mimosaceae (excluding *Prosopis*) presents Richard Cowan's last contribution to plant systematics. I know that Dick thoroughly enjoyed his work on the *Flora of Australia*, and his treatments almost vibrate with the enthusiasm with which he approached his work. The work has obviously benefited from Dick's experience with American Mimosaceae as the groups treated here, especially those in tribe Ingeae, have close relatives in the America's, and Dick's familiarity with those groups adds a certain soundness to his treatments. He is sorely missed.

All in all, this volume is everything it should be: sound, complete, and very practical. I can see that it will be well used by me.

James Grimes



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